CHAPTER SIX
ENVIRONMENT

INTRODUCTION

Chapter Six evaluates selected physical and biological characteristics that are relevant to the consideration of the type and location of future land uses in Carbon County. Selected socio-economic aspects of the regional environment of Carbon County are analyzed in Chapters Three and Four of the Land Use Plan.

Physical resources, such as groundwater resources and wetland areas, represent potential constraints and opportunities to future land uses. For example, the lack of groundwater resources in a geographical area can discourage potential residential development unless potable water resources can be economically transported from an adjoining area to a proposed residential subdivision location. In contrast, existing wetland areas can provide an opportunity to drain, filter and recharge surface runoff into groundwater aquifers, as well as provide potential wildlife habitat.

Wildlife populations are influenced by a variety of environmental factors such as the quality and quantity of habitat, weather, disease, parasites, predation, and hunting (Wyoming Game and Fish Department, 1995). In the context of the Land Use Plan, the type, location and density of future land uses represents an important consideration because of its relationship to the availability and quality of future wildlife habitat.

The evaluations made in Chapter Six identify some of the more important environmental relationships between various types of land uses and physical/biological resources. Significant environmental issues that emerged from this analysis were further addressed through the identification of potential land and resource management options.

THE PHYSICAL ENVIRONMENT

Geology and Geography

General

Carbon County is comprised of approximately five million acres of land area and some 55,059 acres of surface water area. The geologic story behind the County's landscapes and natural resources is one of the oldest and most complex in North America (Snoke and others, 1993).

The primary land feature in the County is the Continental Divide. Within Carbon County, the Continental Divide generally extends from northwest Carbon County through the west and south-central portions of the County. A west rim of the Divide also extends west to east from the west boundary of the County (south of Creston Junction) to an area about 12 miles southwest of Rawlins.

Other prominent land features include the Ferris Mountains and Seminoe Mountains that are generally situated between Muddy Gap and the Seminoe Reservoir. The Shirley Mountains are located generally east of Seminoe Reservoir, as well as north of Hanna and Medicine Bow. The Platte Valley and other portions of southeast Carbon County are characterized by series of mountains and peaks along the Medicine Bow Range that include Elk Mountain, Pennock Mountain, Kennaday Peak, and Bennett Peak.

Carbon County generally includes three hydrologic basins (Figure 6-1). The upland basin boundaries reflect the upper elevations of the continental divide. Significant drainages in the County include the North Platte River, Encampment River, and Medicine Bow Rivers that initially drain into the Seminoe Reservoir, are stored in the Pathfinder Reservoir, and, ultimately, are carried by the North Platte River to Nebraska and other downstream states. Another important drainage in southeast Carbon County is

Figure 6-1
Hydrologic Basins of Carbon County

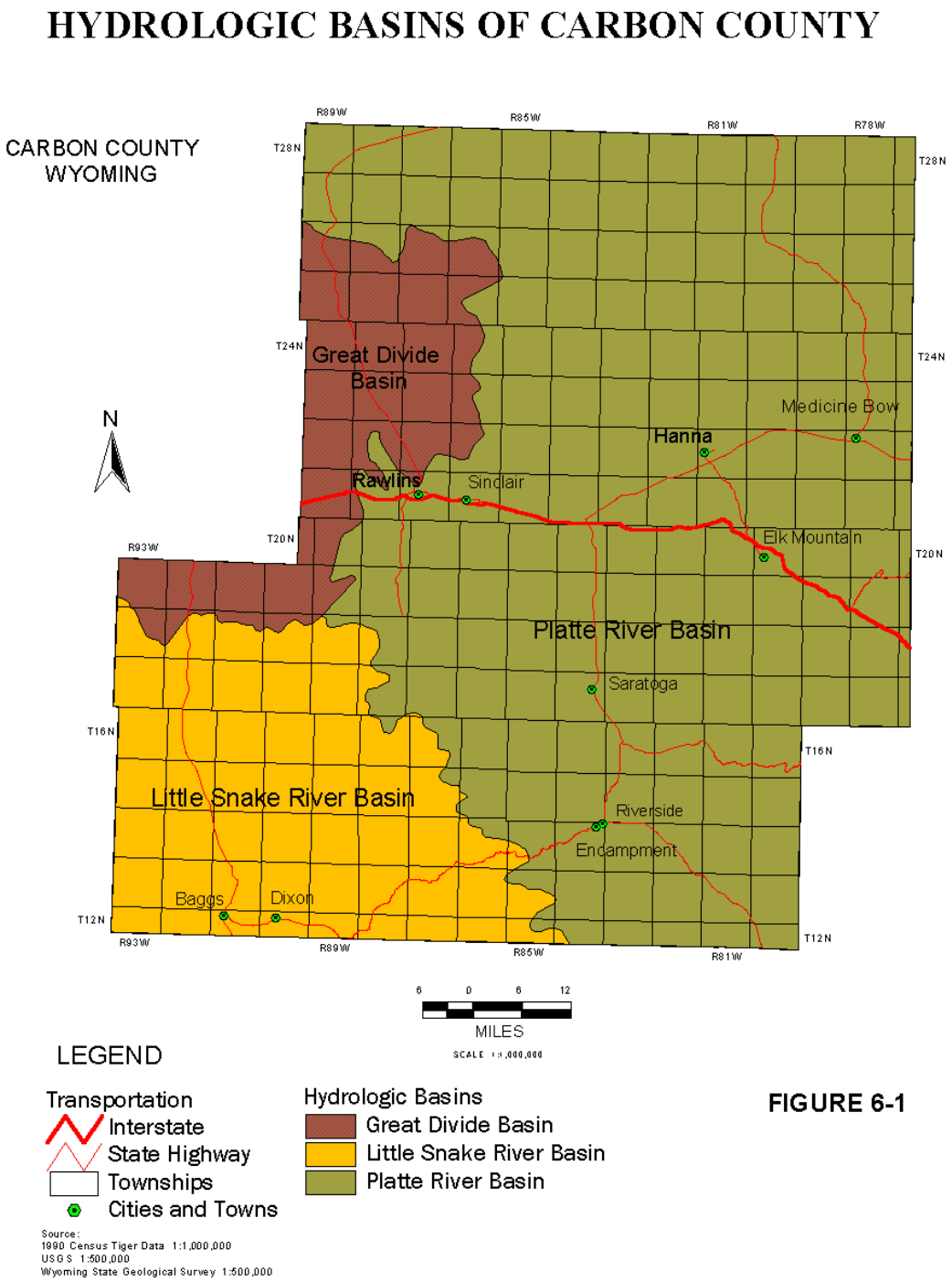

FIGURE 6-1

the Little Snake River that originates within the upper elevations of the Sierra Madre Mountains in Wyoming and Colorado's Routt National Forest.

Great Divide Basin

The east portion of the Great Divide Basin is situated in Carbon County. This portion of the Great Divide Basin includes an area that is south of the Ferris Mountains, west of the Haystack Mountains (along the Continental Divide), northwest of Rawlins, and north of the west rim of the Continental Divide. The Great Divide Basin is topographically closed; surface drainage is internal. The Basin is generally characterized by drier, flat land, sagebrush and prairie lands, and limited rainfall.

Land uses in the basin primarily include cattle ranching. At the same time, oil and gas production, processing, and related product transportation also represent significant land uses in the basin.

No incorporated Carbon County communities are located in this basin. However, the unincorporated village of Lamont is situated near the northern boundary of the basin.

Little Snake River Basin

Within Carbon County, the Little Snake River basin is south of the west rim of the Continental Divide, west of the Sierra Madre Mountains, and north of Colorado's northern border. However, in hydrologic terms, the Little Snake River basin also extends south into northern Colorado. The Little Snake river flows south of Baggs to the Yampa River. The Yampa River flows into the Green River, a tributary of the Colorado River.

Drier flat lands that resemble the Great Divide Basin characterize much of this basin. However, the topography of the south and east part of the Little Snake River basin vary considerably. The agricultural lands along the Little Snake River receive irrigation from the surface waters of the Little Snake River and its tributaries.

Most of the basin is used for cattle ranching and sheep production. Oil and gas production is significant within the northern portion of the Little Snake River Basin. In addition, smaller portions in the east part of the basin are used for limited mining activities, occasional timber harvests, and recreation.

Within this basin, Baggs and Dixon are the sole incorporated municipalities. Unincorporated communities in the basin include the village of Savery.

North Platte River Basin

The remaining part of Carbon County represents a portion of the North Platte River drainage. Within Carbon County, this basin is east and north of the Sierra Madre range and Continental Divide. The basin includes the Seminoe and Pathfinder Reservoirs that provide water storage for surface flows in the basin, as well as water recreation. The northern part of this basin (within Carbon County) represents drier agricultural lands on a gentle to rolling topography. Smaller volcanic mountain ranges intersperse sagebrush and prairie lands. Greater rainfall occurs in the Platte Valley, which is situated generally south of Interstate 80. Significant portions of the agricultural lands in this area are also irrigated via basin surface water supplies. Forested areas are found on the slopes of Shirley Mountain, Elk Mountain, the Medicine Bow range, and the west side of the Sierra Madre range.

The basin is generally used for cattle ranching, underground and surface coal mining and processing, oil and gas production and processing, timber harvests, and recreation. Timber mills and processing facilities are situated in Saratoga, Encampment, and Medicine Bow.

Residential communities in the basin include Rawlins, Sinclair, Hanna, Medicine Bow, Elk Mountain, Saratoga, Encampment, and Riverside. The primary commercial center and county seat in Carbon County is the City of Rawlins.

Mineral Resources

Discussions with representatives of the State Geological Survey office and general surface geology mapping indicate that there are a variety of mineral resources in Carbon County that are conducive to future industrial and hardrock mining opportunities.

Sand and Gravel

Sand and gravel deposits are scattered throughout Carbon County. Significant land areas containing these deposits are generally situated roughly 12 to 20 miles north and northwest of Rawlins. Numerous leases have been issued by Union Pacific Resources within the historical, land grant "checkerboard" to support local construction demands (See, 1996).

Along the North Platte and Little Snake River drainages, there are outcrops of alluvial sand and gravel that contain varying proportions of subrounded to subangular clasts of gravel, sand, and clay. Outcrops of windblown sand are situated in a portion of northwest Carbon County; this area is north of Separation Lake, west of the Continental Divide, and south of the Ferris Mountains. In the north part of Carbon County, outcrop areas of older sand and gravel are located in area that is several miles east of Pathfinder Reservoir.

Limestone

Limestone deposits are found along the flanks of the Rawlins uplift. The deposits are generally located in the Madison formation that primarily contain a cement grade limestone (See, 1996). Other limestone deposits are known to be located on the north side of the Shirley Mountains and the south side of the Ferris Mountains (Harris, 1998).

Bentonite

Large bentonitic clay deposits are located north and southeast of Medicine Bow. These deposits are of Cretaceous age and primarily contained within the Clay Spur Bed (See, 1996). Within Carbon County, most significant deposits have good commercial quality. However, these deposits are generally steeply dipping; consequently, the mining of these resources is less attractive to commercial mining companies (Harris, 1998).

Bentonite historically has been used by the oil and gas industry during exploration drilling. More recently, bentonite has been used as an industrial binder for the production of taconite pellets that are associated with steel production. Various hazardous waste cleanup projects also apply bentonite to establish an impermeable barrier that prevents future contamination to surface and groundwater resources. The production of some "kitty litter" products also contains bentonite (Harris, 1998).

Uranium

Uranium resources are situated in the Shirley Basin. These resources are amenable to in-situ production (Odell, 1998; Harris, 1998).

Other uranium resources are located in the Poison Basin west of Baggs. However, these resources have less development potential (Harris, 1998).

About 95 percent of all uranium is used by the nuclear energy industry. There are some 100 nuclear energy plants in the United States. Since the nuclear energy industry is not expanding in the United States, the future, domestic demand for uranium shows little or no promise for growth. However, international demand for uranium is increasing in the Far East, e.g., China, where the nuclear industry continues to expand (Odell, 1998). In addition, nuclear energy plants in Europe also represent a continued market destination. Wyoming leads the national production of uranium (Harris, 1998). There are three uranium producers in the State that presently mine uranium; a fourth company, Kennecott Uranium Company, is preparing to mine uranium resources in neighboring Sweetwater County near Green Mountain (Odell, 1998).

Decorative and Dimensional Stone

Some of the better red granite in the United States is located south of State Highway 70 and north of the Huston Park wilderness area (southwest of Encampment). In the Seminoe and Shirley Mountain area, there are also deposits of granite that are suitable for decorative stone and aggregate. Various locations also contain moss rock and other decorative stone material that is in demand for residential and commercial construction applications.

Zeolite

Zeolite minerals are situated at the north end of the Sierra Madre near the headwaters of Sage Creek. Zeolite is used as a synthetic mineral filter that absorbs toxic material. One of the primary industrial uses is associated with petroleum refining (Harris, 1998).

Hardrock Minerals

Gold, silver, copper, nickel, cobalt, platinum, and pallidium deposits are known or suspected to be located in, at least, four general areas of Carbon County:

- between the east end of the Ferris Mountains and the Seminoe Mountains;
- the Seminoe Mountains;
- Snowy range area; and,
- most of the Sierra Madre (Hausel, 1998).

Zinc and lead deposits occur south of Encampment near the Wyoming-Colorado border.

Diamonds have been discovered in the Snowy Range area. Host rock minerals associated with diamonds are located in the Medicine Bow Mountains and the Seminoe Mountains.

Coal Reserves

Higher Btu coal, which contains between 8,500 and 10,200 British thermal units per pound, are found in the Hanna Basin. Existing coal reserves are still not depleted northeast and northwest of Hanna. Both Cyprus Amax and Arch of Wyoming plan to continue existing coal mining operations at the Cyprus-Shoshone and Medicine Bow mines (Tanner, 1997; Turner, 1997) through 1999.

Mineable coal reserves are also present in the Carbon Basin area located about 15 miles south of Hanna. Arch of Wyoming plans to begin mining these deposits in the year 2000.

Other coal reserves are situated in other areas on the west side of Carbon County. These areas include Red Rim, China Butte, Indian Springs, North Indian Springs, and Atlantic Rim (U.S. Bureau of Land Management, 1988; Union Pacific Resources, 1997).

Oil and Gas Producing Formations

"The Greater Green River Basin has been a significant regional producer of natural gas for more than 65 years" (Barlow & Haun, Inc., 1995). The eastern portion of this geologic area extends about 10 to 40 miles into the west part of Carbon County. Gas reserves in Carbon County are primarily located in the east sections of the Great Divide and Washakie Basins (De Bruin, 1996). These two basin areas are characterized by stratigraphic traps, and produce from younger geologic formations, e.g., Cretaceous (U.S. Bureau of Land Management, 1987).

Soils

Portions of Carbon County have been surveyed, classified, and analyzed by the U.S. Natural Resources Conservation Service, the Bureau of Land Management, and the U.S. Forest Service. Each of the agencies used different field survey methods, established different orders of soil

classifications, and organized the data for different types of evaluations and data uses. Consequently, there is no definitive and comprehensive source of information that identifies:

- the types and location of soils that are found in Carbon County;
- the general physical characteristics of surface soils; and,
- the suitability of local soils for various types of land uses.

Historically, such information is typically developed, published, and distributed by the Natural Resource Conservation Service for public use. Such information is typically available for most communities in the United States, particularly those areas that contain a strong, agricultural base. NRCS has also prepared comprehensive soil surveys for American Territories such as American Samoa, Guam, and former territories in the present Federated States of Micronesia and Republic of Palau. In this context, it is difficult to comprehend why a comprehensive soil survey for Carbon County has not yet been completed by the Natural Resource Conservation Service. As described in Chapter Three, some $27.3 million of direct expenditures are annually made by commercial agriculture into the Carbon County economy.

The former U.S. Soil Conservation Service (now called the Natural Resource Conservation Service) prepared a very general soils map of Carbon County in August, 1958. The map identifies 25 different types of soil and their general location in Carbon County. However, the information contained on this map has limited use for general land and resource management.

A 1972 soil survey of the Sage Creek watershed evaluated about 185,475 acres near the center of Carbon County. This survey, which was also prepared by the U.S. Soil Conservation Service, identifies 12 soil associations and 59 soil series. Useful physical data and general soil suitability information is provided and represents the scope of information that should be available for the entire County.

Climate

General

The climate in Carbon County varies considerably. Geographical differences in precipitation are evident in various parts of the County (Table 6-1). Diurnal temperature ranges in the County vary significantly. Surface winds are significant in selected areas of the County; other areas of the County experience limited to moderate wind conditions.

Precipitation

Available long-term information indicates that average annual precipitation levels in Carbon County range from about nine to 14 inches per year. Higher precipitation levels occur in the vicinity of Seminoe Dam and Encampment, which receive an average of between 12 and 15 inches of precipitation each year. Rawlins, Saratoga, and the Pathfinder Dam area are characterized by somewhat lower levels of precipitation that range from about nine to 10 inches per year (Martner, 1986).

Available data presents an incomplete picture of the moisture that is received in Carbon County via rainfall and snow. Public records do not reflect the considerably drier areas of the Great Divide Basin and Red Desert area. Local ranchers that have operated in the area for 50 or more years indicate that average annual rainfall in this area is about eight inches or less.

Ambient Temperature

Average ambient temperature levels in Carbon County range from a low of about 22 degrees Fahrenheit in January to about 67 degrees Fahrenheit in the month of July. Greater diurnal temperature variations occur in the month of July when it is not uncommon for average minimum and maximum temperatures to vary 33 to 43 degrees.

TABLE 6-1
AVERAGE PRECIPITATION
SELECTED LOCATIONS WITHIN CARBON COUNTY
1961-1990
(In Inches Per Month)

Location	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
Elk Mtn.	0.76	0.71	1.05	1.50	1.59	1.29	0.92	0.94	1.04	1.03	1.00	0.76	12.59
Encamp-ment	0.71	0.82	1.19	1.60	1.56	1.33	1.37	1.40	1.29	1.31	1.04	0.89	14.51
Medicine Bow	0.47	0.53	0.77	1.22	1.34	1.22	1.10	0.87	1.04	0.86	0.62	0.59	10.63
Pathfinder Dam	0.32	0.39	0.64	1.18	1.77	1.22	0.90	0.62	0.74	0.87	0.52	0.38	9.53
Rawlins Airport	0.52	0.50	0.69	1.01	1.21	0.88	0.86	0.84	0.93	0.90	0.61	0.58	9.53
Saratoga	0.41	0.48	0.75	1.04	1.25	0.96	1.18	0.91	0.96	0.96	0.63	0.52	10.05
Seminoe Dam	0.61	0.67	1.10	1.73	2.12	1.43	1.02	0.81	1.03	1.23	0.93	0.74	13.42

Source: U.S. National Oceanographic and Atmospheric Administration, National Weather Service, 1991

Long-term data from the 1951-1988 period indicate that the lowest recorded daily temperatures in the County occurred in Medicine Bow and Encampment. The National Weather Service recorded January temperatures of –46 degrees Fahrenheit in these two communities.

The highest recorded daily temperature during the 1951-1988 period occurred in Saratoga during one day in July when the ambient temperature rose to 100 degrees Fahrenheit. Temperatures in the 97 and 98 degree level were also documented in the communities of Medicine Bow and Rawlins.

Surface Winds

Available surface wind information suggests the surface winds predominantly blow from the southwest. Rawlins, for example, generally experiences westerly and southwesterly winds. Medicine Bow also receives southwesterly winds, but not as consistently as Rawlins. Unrecorded informal observations in the lower Platte Valley, north of Encampment, suggest that southwest winds are also prevalent in this part of the County.

In terms of velocity, strong winds are a regular occurrence in the vicinity of Arlington. Available information for the 1974-1981 period documented an average wind speed of almost 16 miles per hour.

In nearby Medicine Bow, available data from three area locations during the 1976-1981 period indicate that average velocities are between 12 and 13 miles per hour. Wind speeds that were recorded in the Elk Mountain area between 1975 and 1981 were approximately 13 miles per hour (University of Wyoming, Department of Atmospheric Sciences, 1995).

In the Red Desert area, short-term information that was obtained between 1976 and 1979 suggest that wind speed may average about nine miles per hour. Residents familiar with this area indicate that considerably higher winds frequently occur.

WATER RESOURCES

Ground Water

General

Historical groundwater reconnaissance studies, oil and gas well data, and other general information sources provide only a limited picture of the available ground- water potential in Carbon County. The general conclusions from selected studies are briefly summarized in the following paragraphs.

While available information provides some general indications, this information is inadequate for the determination of land use management decisions. For this reason, it is important that the general ground water potential in Carbon County is mapped and analyzed by a qualified hydrogeologist(s). It is envisioned that the State Engineers Office, State Geological Survey office, and the University Water Resources Research Center could provide resources to complete this task. In the absence of such information, the Carbon County Planning Commission lacks an important type of information that is required to make effective land use management decisions.

In this regard, the State Geological Survey office and University of Wyoming, Water Resources Research Center, are presently undertaking a hydrogeologic and geochemical study of the Little Snake River drainage, as well as a portion of the Great Divide basin. Completion of this study is expected in early 1998 (Case, 1997). Some of the information that will be derived from this study will be helpful to Carbon County. However, further coordination with Carbon County is necessary to ensure that study results can be applied to pressing local land management issues.

In the following discussion of groundwater resources, the potential sources of groundwater and known groundwater quality are aggregated for the three hydrologic basins in Carbon County. While the areal extent of groundwater aquifers do not coincide with the boundaries of surface water hydrology, they are important in terms of the consideration of future recharge to groundwater aquifers.

Great Divide Basin

Potential Sources of Ground Water

The Great Divide Basin, also known as the Red Desert Basin, is separated from the Little Snake River Basin by "….*a broad subsurface uplift called the Wamsutter arch*". A groundwater reconnaissance report of this area was prepared by George (Pete) Dana in 1962. The description of groundwater characteristics of the area was expanded somewhat by a 1981 report that was prepared by the Water Resources Research Institute in 1981.

The Dana report indicates there are several primary geologic formations that are known aquifers over fairly large areas. Within Carbon County, these areas are situated in the Tensleep, Lakota, and Chugwater formations. These aquifers are generally located in the central and north parts of the Rawlins Uplift.

Dana also indicates that artesian waters may be situated in two additional areas of the Great Divide Basin in Carbon County:

- southwest of Rawlins on the eastern dip slope of the Washakie Basin; and
- in the vicinity of former oil field areas between Rawlins and Muddy Gap where artesian zones in the Frontier, Dakota, and Sundance beds are recorded.

The recharge of aquifers and artesian sources in the Great Divide Basin are derived from infiltration of snowmelt and surface runoff. All surface runoff drains toward the center of the Basin into a number of streams and lakes which have no outlets (Dana, 1962).

Potential Quantities of Ground Water

A very general mapping of available groundwater resources was prepared by the U.S. Soil Conservation Service in 1978 in conjunction with studies for the Green River Basin (Figure 6-2). The existing map suggests that groundwater quantities are probably less than 50 gallons per minute. The potential depth to ground water is depicted to vary between less than 100 feet to 300 feet. Some smaller areas, e.g., north of Rawlins and the south side of the Ferris Mountains, are identified as areas where ground water is generally not available (U.S. Department of Agriculture, Soil Conservation Service, 1978).

Little Snake River Basin

Potential Sources of Ground Water

Eight primary aquifers are found in the Little Snake River Basin:

1. *"Quaternary deposits occur largely along the floodplains of the Little Snake River and its major tributaries. These deposits consist of unconsolidated sands, silts, clays and gravels. The maximum thickness of these sediments is approximately 70 feet.*

   The alluvium along the Little Snake River contains hundreds of wells for which yields of 25 to 50 gpm are common. The Town of Baggs, Wyoming has an infiltration gallery near the river which has a reported yield of 800 gpm and one well near Dixon, Wyoming has a reported yield of 300 gpm.

   Small areas of sand originally deposited by wind and later covered by other materials can be found in the region. These deposits typically range in thickness from 50 to 70 feet. Yields of 5 to 25 gpm have been reported from a limited number of wells in these deposits. Because of their limited areal extent, the total yield from one of these deposits is probably less than 50 gpm" (Stone and Webster Engineering Corporation, 1987).

2. *"Upper Tertiary Aquifers consist of sandstones and conglomerates of the Browns Park and North Park formations. The thickness of these formations vary from 0 to 1,200 feet within the study area. Well yields of 30 gpm are common for these formations. Aquifer transmissivities of 100 to 1,500 gallons per day per foot (gpd/ft) have been calculated from the results of pump tests on wells in the North Park formation"* (Stone and Webster Engineering Corporation, 1987).

3. *"Tertiary aquifer system. Several separate formations comprise this aquifer system. These include the Laney Member of the Green River formation, the Cathedral Bluffs tongue of the Wasatch formation, the Tipton tongue of the Green River formation, the main body of the Wasatch formation, the Battle springs formation, the Fort Union formation, and the Lance formation. These formations are exposed over much of the western half of Carbon County, Wyoming, or underlie thin Quaternary deposits. The maximum thickness of this aquifer system is estimated to be between 12,000 and 14,000 feet. Major aquifers within the system are the sandstones of the Wasatch formation, Fort Union formation, the Laney Member of the Green River formation and the Battle Spring formation. Well yields of 5 to 100 gpm have been reported for the various members of this aquifer system"* (Stone and Webster Engineering Corporation, 1987).

4. *"The Mesaverde aquifer crops out in a north-south band across the central portion of the study area. It consists of fine- to medium-grained sandstone with interbedded shale, lignite and coal in local areas. Well yields of 1.5 to 500 gpm have been reported with values of 10 to 25 gpm common"* (Stone and Webster Engineering Corporation, 1987).

FIGURE 6-2
GENERAL AVAILABILITY OF GROUND WATER
GREEN RIVER BASIN

FIGURE NOT AVALIBLE

"The Frontier aquifer is exposed along Big Sandstone and Battle Creeks and consists of sandstone shale with a few beds of bentonite and lenses of pebble conglomerate. Only one permitted well located within the study area is now yielding water from the Frontier aquifer. Yields from wells outside the study area in this aquifer vary widely, with yields of 1 to over 100 gpm reported" (Stone and Webster Engineering Corporation, 1987).

5. *"The Cloverly aquifer consists of an upper sandstone unit and a lower conglomerate unit. Its thickness ranges from 45 to 240 feet and it crops out in the study area near the Sierra Madre uplift. This unit dips to the west and near Baggs it occurs at a depth of over 13,000 feet. Water wells in the vicinity of Rawlins, Wyoming have yields ranging from 25 to over 120 gpm"* (Stone and Webster Engineering Corporation, 1987).

6. *"The Sundance-Nugget aquifer is composed of fine-to medium-grained sandstone, interbedded with some shale, siltstone and limestone. Both formations crop out near the Sierra Madre and Rawlins uplifts and together, have a maximum thickness of between 170 and 1,100 feet. Only one well has been identified within the study area which is completed in these formations. This well has a reported yield of 28 gpm"* (Stone and Webster Engineering Corporation, 1987).

7. *"The Paleozoic aquifer system consists of all rock units below the Chugwater formation. Important water-bearing units are the Tensleep Sandstone, the Madison Limestone, and unidentified Cambrian and Precambrian rocks. Only limited information on wells completed in this aquifer system is available within the study area. Based on information from wells located in the Rawlins area, well yields of 4 to 400 gpm can be expected"* (Stone and Webster Engineering Corporation, 1987).

Potential Quantities of Ground Water

In 1987, a study of State Engineer Office groundwater well records in the Basin revealed that authorized wells were yielding flows between 0.25 and 500 gallons per minute (gpm). The average groundwater yield was about 22 gallons per minute.

However, most wells in the Basin are shallow, low-yielding wells which have typically been drilled to depths less than 500 feet. These shallow wells typically yield a supply that ranges between five and ten gallons per minute. Roughly 24 percent of the draw is obtained from alluvium sources that are primarily located along the Little Snake River (U.S. Army Corps of Engineers, Omaha District, 1988).

Platte River Basin

Potential Sources of Ground Water

Alluvial aquifers are found along the North Platte and Medicine Bow Rivers. These areas are characterized by stream deposited gravel, sandstone, and boulders (Dana, 1962).

Upper tertiary aquifers consist of sand mixed with silt-stone, clay with thin standstone, limestone, and volcanic rock of the Browns Park and North Park formations. Ground water from these formations have occurred northeast of Encampment, as well as north of Saratoga in the Pass Creek Flats area (Dana, 1962).

Upper tertiary aquifers are also found in the White River and Hanna formations. The White River formation is primarily characterized by sandstone, siltstone, shale, and marlstone. The Hanna formation is a sandy shale, massive sandstone, conglomerate with a thin layer of coal and shale. The occurrence of ground water in White River formations have been reported in the Shirley Basin. Ground water in the Hanna formation have occurred in, at least, the northern edge of the Hanna Basin (Dana, 1962).

Lower cretaceous aquifers are present in the sandstone of the Dakota and Lakota formations. Groundwater occurrences have been reported in the southern edge of the Shirley Basin (Township 26N, Range 80 and 81W). Ground water from the Lakota formation has also occurred in the same area (Dana, 1962).

Artesian waters that may be suitable for future artesian well development are scattered throughout the Basin. In the Dakota formation, such occurrences have been reported east of the Shirley Mountains, northeast of Saratoga, and the northern fringe of the Hanna Basin (Dana, 1962).

Potential Quantities of Ground Water

The greatest volumes of ground water are being obtained from the alluvial aquifers along the North Platte River. In the past, significant amounts of ground water, i.e., approximately 5,000 gpm, were also pumped from aquifers in the Shirley Basin by the Utah Mining Company.

A very general mapping of available groundwater resources was prepared by the U.S. Soil Conservation Service in 1979 in conjunction with studies of the Platte River Basin (Figure 6-3). The existing map suggests that groundwater quantities are probably less than 50 gallons per minute in most areas of the Platte River Basin.

Two major exception are the alluvial aquifers along the North Platte River and Medicine Bow River which are depicted to supply between 50 and 450 gallons per minute. A sizeable area that is situated southeast and northwest of the Encampment-Riverside area is also suggested to provide potential groundwater yields between 50 and 450 gallons per minute. The area extends roughly from the Colorado border to Jack Creek (west of Saratoga).

South of Elk Mountain and downslope of the western slopes of the Medicine Bow Mountain, the U.S. Soil Conservation estimates that ground water is generally not available, or is only found in depths greater than 600 feet. Similarly, ground water is generally not considered available in some of the area north and east of Seminoe Reservoir and Kortes Dam (U.S. Soil Conservation Service, 1979).

Within the Sage Creek watershed (south of Rawlins), the general depth to ground water ranges between 600 and 3,500 feet. Between Walcott Junction and Medicine Bow, the potential depth to ground water is between 300 and 600 feet (U.S. Soil Conservation Service, 1979).

Surface Water

Great Divide Basin

Streams in the Great Divide Basin flow intermittently. Stream courses flow primarily in response to direct runoff from rainfall and snowmelt (U.S. Department of Geological Survey, 1976).

In the southeast part of the Great Divide Basin, Fillmore Creek is a primary stream. Even so, surface flow from this stream is intermittent. Occasional surface flows are carried northeast into Separation Creek which drains into Separation Lake.

Streamflow data is not available for Fillmore Creek (Barlow and Haun, Inc., 1994). Available data for Separation Creek includes flows from only July through September, 1975. Sporadic flows, which ranged between 8 and 22 cubic feet per second (cfs) occurred during this period. However, this data cannot be assumed to represent long-term conditions.

Coal Bank Creek and Bad Water Creek also represent other intermittent channels along the north side of the Basin's west rim. However, there is no available data that documents surface flows from these intermittent water bodies.

FIGURE 6-3
GENERAL AVAILABILITY OF GROUND WATER
PLATTE RIVER BASIN

FIGURE NOT AVALIBLE

Little Snake River Basin

General Drainage Characteristics

Surface water bodies within the Little Snake River Basin are part of the Colorado River watershed. The primary tributary from Carbon County that carries surface water into the Colorado River watershed is the Little Snake River. *"The Little Snake River drains approximately 4,000 square miles in south-central and north-central Colorado from its headwaters in the Sierra Madre mountains to its confluence with the Yampa River"* (U.S. Army Corps of Engineers, Omaha District, 1988).

The portion of the Little Snake River Basin, which is located in Carbon County, lies north of the Colorado border and is bounded by the Continental Divide. Within Carbon County, principal tributaries to the Little Snake River include Savery Creek, Battle Creek, and Muddy Creek. Surface flows from the southwest slopes of the Continental Divide are the primary source of surface runoff to these and other tributaries.

Savery Creek is the largest tributary of the Little Snake River which is situated upstream from Baggs. The primary tributaries to Savery Creek include the east and north forks of the Creek, Little Savery Creek, as well as Big and Little Sandstone Creeks.

Battle Creek also originates along the southwest slopes of the Continental Divide. Its tributaries include the north fork of Battle Creek and Haggarty Creek.

Muddy Creek, which begins on the southwest slope of the Sierra Madre and Continental Divide, contains many smaller tributaries. Barrel Springs Draw and other smaller drainage courses drain into Muddy Creek from the west. Grave, McKinney, and Littlefield Creeks drain the upper slopes of the upper Muddy Creek drainage. Lower elevation tributaries from the east side of the drainage include Dry Cow Creek, Wild Cow Creek, Cherokee Creek, Deep Creek, and other smaller drainage courses.

Muddy Creek contains intermittent surface flows that are generated from snowmelt conditions, and stormwater flows following short duration rainfall events. Between 1988 and 1991, mean daily flow in Muddy Creek averaged about 15 cubic feet per second (cfs) near Baggs. Higher flow conditions occurred during the March-May period when 30 to 60 cfs flows were recorded. Lower flows were documented during the months of January and February when flows average about 0.5 cfs (Barlow and Haun, Inc., 1994).

In general, annual streamflow volumes within the Little Snake River Basin vary considerably. Snowmelt provides a significant portion of their annual flow. About 85 percent of the annual surface flow occurs in the months of April through June with the greatest flows occurring during the month of May (Table 6-2). Lower flows take place during July through September.

Streamflow Availability and Depletion

"The Colorado River Compact of 1922 allocates consumptive uses of water in the Colorado River drainage between the Upper Basin states (Wyoming, Colorado, New Mexico, Utah) and the Lower Basin states (Arizona, Nevada, California). Among other provisions, the compact allocates the consumptive use of 7.5 million acre-feet of water to each of the two groups."

The Upper Colorado River Basin Compact divides the Upper Basin allocation among the four states. Wyoming's allocation is 14 percent of the Upper Basin allocation and amounts to a consumptive use of 1.043 million acre-feet of water per year on the basis of 7.5 million acre-feet being available for use in the Upper Basin. Deducting Wyoming's present consumptive uses of 315,700 acre-feet per year from the 1.043 million acre-foot allocation leaves 727,300 acre feet per year available for new consumptive uses. The Colorado River drainage, however, has not produced the amount of water estimated at the time the compacts were

TABLE 6-2
INSERT
LITTLE SNAKE RIVER BASIN STREAMFLOWS

TABLE NOT AVALIBLE

agreed upon. If the water supply does not reach the volumes used to derive the compacts, Wyoming may be limited to 455,000 acre-feet of additional consumptive uses (Ostresh, Marston, and Hudson, 1990).

It is estimated that there are roughly 18,240 acres of irrigated agricultural land in the Little Snake River Basin (Vigil, 1998). In a given year, between 70 to 80 percent of these lands are irrigated (Worthington, 1998). It is important to note that water rights in both Wyoming and Colorado are used to irrigate lands in the Little Snake River Basin. Colorado authorizes the use of one cubic foot per second for every 60 acres of irrigated land; Wyoming permits the use of one cubic foot per second for every 70 acres.

Upper North Platte River Basin

General Drainage Characteristics

Within Carbon County, the Upper Platte River Basin generally receives surface flows from various streams that ultimately drain into the North Platte River and the Medicine Bow River. These flows continue downstream to the Seminoe and Pathfinder reservoirs.

Surface runoff originates generally from the upper slopes on the north and west slopes of Medicine Bow Mountains, as well as the east and northeast slopes of the Continental Divide. The Encampment River, for example, carries surface flows from the northeast slopes of the Continental Divide near the Colorado River to its confluence with the North Platte River, about seven miles northeast of Encampment.

Other than the Encampment River, principal drainage courses in the Platte Valley that drain into the North Platte River include Sage Creek, Beaver Creek, Spring Creek, Brush Creek, and Pass Creek.

The Medicine Bow River primarily receives surface drainage that is contributed by streams on the north and east sides of Elk Mountain, the north and east slopes of Kennaday Peak, the north and west slopes of Lookout Mountain, as well as the southern slopes of the Shirley Mountains.

The Upper North Platte River Basin, upriver of the Pathfinder Reservoir, receives approximately 68 percent of the annual surface flow occurs in the months of April through June (Table 6-3). The greatest flows occur during the months of May and June; lower flows take place from December through February.

Streamflow Availability and Depletion

"During the drought of the 1930s, Nebraska brought suit in the U.S. Supreme Court against Wyoming and Colorado over administration of the waters of the North Platte River" (Ostresh, Marston, and Hudson, 1990). The decree issued in 1945, and amended in 1952, stipulates, in part, that:

- Wyoming cannot irrigate more than 168,000 acres of land above the Guernsey Reservoir and from the tributaries upriver of the Pathfinder reservoir.

- Wyoming cannot store more than 18,000 acre feet of irrigation water from the North Platte River above the Pathfinder Reservoir.

In 1996, there were approximately 143,758 acres of irrigated land above Pathfinder reservoir. Approximately 85 percent of these lands, or about 122,194 acres, were located in Carbon County (Fassett, 1998). The lands were irrigated to support hay and forage production on range land areas.

table 6-3
upper north platte river basin
surface flows

TABLE NOT AVALIBLE

Water appropriators are authorized to use surface waters during the irrigation season defined in the Nebraska vs. Wyoming decree. The irrigation season extends between May 1 and September 30 of a given year. Each irrigator is authorized to use one cubic foot per second of surface water per 70 acres during a given season. In 1989, the State of Wyoming indicated that it would regulate the distribution of surface water to adjudicated North Platte water users between October 1 and May 1 of any given year.

Regional Water Resources Issues

Introduction

There are various water resource issues that confront Carbon County. The Land Use Plan does not attempt to address all relevant issues. Rather, three significant issues are briefly summarized that will have a significant impact upon future land uses.

Conservation of Irrigated Lands

The future use of lands in Carbon County is dependent upon the availability of future water resources. Irrigated agricultural lands are located in significant portions of the Upper North Platte River Basin and the Little Snake River Basin. Ongoing agricultural activities ensure that adjudicated diversions and authorized water consumption will remain. However, the amount of available surface water supplies can reduce significantly with future changes in land use. For example, if a ranch with some 500 irrigated acres of land is developed for a residential subdivision, the State Engineer's Office will likely reduce authorized consumption to approximately 40 percent of its previous allocation for agricultural purposes. A reduction or elimination of water applications to the soils of former irrigated agricultural lands, as well as the discontinued use of existing water diversion systems, will:

- reduce soil saturation;
- reduce return flows to existing rivers and tributaries;
- significantly impact the quality and amount of forage available for big game animals;
- eliminate some wetlands and reservoirs that provide valuable wildlife habitat;
- reduce or degrade aquatic habitat in the Little Snake River, North Platte River, and their tributaries; and,
- gradually erode Carbon County's agricultural economic sector.

Carbon County desires to conserve its irrigated lands. It recommends that Carbon County evaluate future options for the conservation of irrigated lands in the Little Snake River and Upper North Platte River basins. The review of potential options should be made in close coordination with local water appropriators, the State Engineer's Office, and the State Conservation Districts.

Platte River Endangered Species Partnership

In July, 1997, the U.S. Department of Interior and the states of Nebraska, Wyoming and Colorado entered into an agreement to address endangered species issues related to the Platte River Basin. A 10 to 13-year program is envisioned by the participating agencies to:

- Secure sufficient improvements to the Platte River habitat for the whooping crane, piping plover, interior least tern, and pallid sturgeon so that existing and future water use in the Platte River Basin is not likely to jeopardize any of the four species.
- Bring existing and new water uses in compliance with the federal Endangered Species Act.
- Prevent other species in the Platte River Basin from becoming threatened or endangered.
- Ensure that any impacts on the Central Platte habitat from future water development in each state are prevented or offset within that state.

This cooperative program seeks to allocate some 34,000-acre feet of surface water from the Upper North Platte Basin for the conservation of three bird species and one fish species in central Nebraska. While preliminary conservation objectives are considered desirable, proposed methods of achieving

increased fish and wildlife conservation may eventually lead to significant impacts upon agriculture in Carbon County. Land use changes resulting from potential impacts upon agriculture might also generate new land uses that would adversely impact wildlife habitat in Carbon County.

Potential Impacts Upon Agriculture

In the context of the cooperative program, the Upper North Platte River Water Users Association points out that the State's ongoing regulation of surface waters between October 1 and May 1 of a give year could adversely impact "junior" users who usually need to begin irrigation about April 1. "Senior users" have initial priority for the receipt of surface water from the North Platte. "Junior" users must wait for the distribution of water allocations to senior users before they can receive their junior appropriations. In the potential absence of water until May 1, livestock production in some years could be adversely affected as more hardened soils will become less capable of promoting the growth of grasses and the production of hay.

The concern is for drier years when the amount of available water from the North Platte River is limited. Under these circumstances, the availability of water for agriculture is already tenuous. If additional water uses are made for fish and wildlife conservation in Nebraska's Central Platte River Basin, more frequent shortages will likely occur in drier years. These periodic events would more likely impact junior agricultural appropriators that are upriver of the Pathfinder and Seminoe Reservoir. Some of these agricultural operations would become discouraged from less desirable range land conditions, lower hay production yields, and reduced gains in livestock. Ultimately, reduced profits would lead to the sale of ranch properties.

The number of ranch operations that would be adversely affected by this operation is difficult to estimate. Carbon County has approximately 286 commercial ranch operations. In 1996, there were about 122,194 acres of land that were irrigated through the diversion and use of surface water from the Upper North Platte River. It is estimated that roughly 100 operations contain irrigated acreage that could be impacted by the cooperative agreement.

In economic terms, the average ranch in Carbon County annually expends approximately $154,151 (1995 dollars) to support ranch operations. About 62 percent of these expenditures, or approximately $95,574, are made within Carbon County. If 100 appropriators are adversely impacted to the point that their ranch operations are eventually discontinued, the regional economy of Carbon County could annually lose approximately $9.6 million in direct expenditures and some $5.3 million of indirect expenditures in retail trade, as well as professional and other services.

Recommendations

Carbon County supports the general conservation objectives of the proposed cooperative program. However, the County believes that other more practical options are available that would pose little or no potential impact upon agricultural interests, fish and wildlife habitat, and water resources in Carbon County. These options include, at least, the following:

- Federal agencies, e.g., the U.S. Forest Service, could use their authority to manage their resources to increase water yields that could flow into the North Platte River.
- The establishment of "willing buyer-willing seller" opportunities could enable some private landowners and agricultural interests to sell their water rights to the federal government.
- Existing and new groundwater supplies in Nebraska could be purchased, developed, and discharged into the North Platte River.

It is also essential that any loss in water rights, which would result from any future program alternative, would adequately compensate private landowners and agricultural interests.

Surface Water Quality

The U.S. Clean Water Act requires Wyoming and other states to prepare a list of surface waters that may be impaired by one or more water pollutants. The draft 1998 Impaired Stream List, also known as the 303(d) list, is a consequence of Clean Water Act requirements. This list, which is updated every two years, contains 13 stream segments within Carbon County (Table 6-4).

The Clean Water Act directs states to develop total maximum daily loads (TMDL) for all water bodies that are identified on the Impaired Stream List. A TMDL is the theoretical, maximum pollutant load that a water body can handle and still support beneficial uses such as agriculture, fisheries, recreation, drinking water, and scenic values.

TABLE 6-4
DRAFT 1998 IMPAIRED STREAM LIST
CARBON COUNTY, WYOMING

Hydrologic Basin	Stream	Location	DEQ Stream Classification*	Credible Impairments
Little Snake River	Haggarty Creek	From Ferris-Haggarty Mine to an unknown distance below highway.	2	Silver, lead, copper, cadmium
Little Snake River	Littlefield Creek	All above Muddy Creek	2	Silt
Little Snake River	Loco Creek	Above confluence with West Fork of Loco Creek	2	Silt, nutrients, temperature
Little Snake River	Loco Creek	Below confluence with West Fork of Loco Creek	2	Silt, nutrients, temperature
Little Snake River	Loco Creek	All above Loco Creek	2	Silt, nutrients, temperature
Little Snake River	McKinney Creek	All above Muddy Creek	2	Silt
Little Snake River	Muddy Creek	West of State Highway 789	3	Silt, salinity, total dissolved solids
Little Snake River	Muddy Creek	Above Alamosa Gulch	2	Silt
Little Snake River	Savery Creek	Between Little Sandstone Creek and North Fork of Savery Creek	2	Silt
Little Snake River	Little Snake River	Unknown distance below Dixon WWTP	2	N/A
Upper North Platte River	North Platte River	Unknown distance below A Bar A WWTP	1	N/A
Upper North Platte River	North Platte River	Unknown distance below Saratoga WWYP	1	N/A

*Note:
State DEQ Stream classifications:

1 Waters with the highest natural water quality and/or other qualities with extraordinary value to the people of Wyoming.
2 Cold water game fishery.
2WW Warm water game fishery.
3 Non-game fishery.
4 Waters without the natural water quality to support fish.

Source: State Department of Environmental Quality, Water Quality Division

A TMDL can be developed for different types of pollutants, i.e., sediment load, phosphorus, acidity, and metal levels, and water temperature. Sediment is the primary source of non-point source pollution in Carbon County. TMDL can also be based upon standards such as a percent reduction in sediment load, or a percent reduction in average annual bank erosion. The Wyoming Department of Environmental Quality has encouraged the establishment of local watershed stakeholder committees to address TMDL issues and encourage public participation.

Section 319 of the Clean Water Act focuses on non-point source pollution. This program developed as a voluntary approach to reducing non-point source pollution through cooperative projects that are initiated by agencies such as State Conservation Districts. All three Conservation Districts in Carbon County are actively involved in voluntary watershed projects to reduce non-point source discharges in the surface waters of Carbon County.

The three Conservation Districts in Carbon County, as well as two other Conservation Districts in the upper North Platte River watershed, have jointly applied for a 205(j) grant from the Wyoming Department of Environmental Quality to continue their respective water quality monitoring programs. If approved, potential grant funds would enable the Districts to gain additional technical training, standardize sampling procedures, and purchase equipment. The Carbon County Board of Commissioners has endorsed this project through a resolution of support.

Water quality will continue to be an important issue to the residents of Carbon County. The quality sampling programs that the Conservation Districts have initiated will continue to provide valuable information. With participation in future monitoring, greater local participation can be contributed to future surface water quality and related TMDL issues. In this regard, it is recommended that the local Conservation Districts would provide the Board of County Commissioners with periodic reports concerning the status and findings of long-term water quality monitoring.

Flood Potential

A review of the Flood Insurance Rate maps for Carbon County, which were published by the Federal Emergency Management Agency in 1987, indicate that the flood potential of Carbon County is limited. Most flood prone areas are situated within or adjacent to the urbanized communities of the County which are located along or near primary drainage areas.

Within the Little Snake River Basin, there is flood potential along the Little Snake River in the vicinity of Baggs and Dixon. Available FEMA maps also indicate flood prone areas along portions of Muddy Creek, Willow Creek, Cottonwood Creek, Savery Creek, and Battle Creek.

Flood potential within the North Platte Basin is along portions of the North Platte River and Encampment River. This flood potential has historically impacted the Town of Saratoga and the Town of Riverside. However, flood prone areas are confined to narrow flood plains along tributaries such as Jack Creek and Spring Creek, which are characterized by limited rural, residential development.

WILDLIFE RESOURCES

Big Game Animals

General

Big game animals in Carbon County include the pronghorn antelope, mule and white-tailed deer, elk, big horn sheep, moose, mountain lion, and black bear. Because of the less developed, rural nature of Carbon County, many of these animals roam freely through many portions of the County. However, the habitat and migration characteristics of these animals vary.

Some animals such as moose and big horn sheep tend to concentrate in one or more areas of the County. Other animals, e.g., pronghorn antelope, tend to be more migratory and can move over 250 miles in one day during fall and spring migration (Wyoming Game and Fish Department, 1991).

Pronghorn Antelope

With the exception of conifer forests, the pronghorn antelope is present throughout most of Carbon County. Available seasonal range maps indicate that crucial winter ranges of the pronghorn antelope are primarily found in the following areas within Carbon County:

- northwest and west of Rawlins in the Red Desert area,
- southeast and north of the Ferris Mountains,
- south of Muddy Gap Junction,
- north of Sinclair,
- within a north-south corridor that is situated east of Baggs,
- east of Riverside near Big Creek, and,
- northeast of Medicine Bow.

However, the antelope is highly migratory. Many areas of Carbon County have relatively high densities of pronghorn antelope during the summer and fall months, but few or none during the winter.

Its habitat generally includes grasslands and sagebrush communities. The antelope prefer flat to gentle rolling topography, with short vegetation. This environment, combined with the antelope's keen vision and ability to move quickly, enable antelope to evade predators (Wyoming Game and Fish Department, 1991).

Antelope also forage within drainages to seek other types of vegetation. During the winter, ridges with wind-blown, snow-free areas also provide antelope with convenient access to forage and enhance the ability of the antelope to survive more severe winter conditions (Wyoming Game and Fish Department, 1991).

The diet of the antelope varies throughout the year. Green grasses are selected during the spring. During the summer, grasses mature and antelope shift their attention to broad-leafed forbs. By late summer and early fall, antelope begin to seek more browse (leaves, stems, and buds of woody plants). After leaves fall from deciduous browse, antelope primarily consume sagebrush (Wyoming Game and Fish Department, 1991).

Higher antelope densities are generally found in areas where a source of surface water is available between one and five miles. When fawns are young in late May and early June, antelope tend to locate within 700 yards from surface water supplies. The proximity to water is necessary to meet doe requirements for milk production (Wyoming Game and Fish Department, 1991).

Mule Deer

Mule deer are highly migratory and roam throughout much of Carbon County. A review of available seasonal range maps suggest that crucial winter ranges for the mule deer are primarily found in the following areas within Carbon County:

- northwest and east of Medicine Bow (north of State Highway 30 and 287),
- Platte Valley,
- east of Rawlins, north and south side of Interstate 80,
- north of Sinclair, and,
- the Little Snake River drainage.

During spring, summer and fall, mule deer are found in suitable habits throughout the County.

Mule deer use a wide variety of habitats. These deer are found in forested areas at higher elevations, riparian areas and lowland drainages, juniper-ponderosa pine breaks and ridges, brushy foothill areas, and occasionally above the timberline.

Mule deer are primarily active during the late afternoon, early evening, and early morning. During midday, deer bed down where there is suitable cover that conceals their presence and a possible escape route from predators (Wyoming Game and Fish Department, 1978). In contrast to the white-tail deer, mule deer generally do not seek areas that are characterized by heavier cover.

The diet of the mule deer is seasonal and is modified with changes in climate and vegetation. During spring, mule deer seek greening grasses. As new forb and shrub growth takes place, these forage opportunities are incorporated into their diet. In the summer months, shrub and forb consumption remains high. Mule deer continue to seek grasses, but the use of grasses decreases considerably. By fall, mule deer continue to seek forbs, but begin to seek shrubby vegetation as a primary source of food. If rainfall generates the growth of cool season grasses, mule deer will also pursue the consumption of grasses.

The lack of food sources during the winter months requires the deer to limit their consumption to trees and shrubs. Browse (leaves, stems, and buds of woody plants) represents, at least, 75 percent of the winter mule deer diet. Strickland investigated mule deer characteristics in the Medicine Bow Mountains in the early 1970's. This study indicated that the winter diet primarily included sagebrush, antelope bitterbrush, mountain mahogany, and rabbitbrush (Wyoming Game and Fish Department, 1978).

Deer drink surface water when it is available. However, mule deer can survive for extended periods without water. During the winter months, mule deer frequently use snow as a source of moisture.

White-Tailed Deer

White-tailed deer are generally common in selected areas of Carbon County, but are significantly less present than mule deer. While-tailed deer are more concentrated in areas such as the North Platte River drainage.

White-tailed deer use a wide variety of habitats that include coniferous and deciduous forest areas, shrubland, agricultural cropland, riparian areas, and moist mountain meadows (Wyoming Game and Fish Department, 1995). However, white-tailed deer thrive more in wooded draws where there is greater cover, the availability of forbs, and fawning habitat (Wyoming Game and Fish Department, 1993).

The diet of white-tailed deer is similar to mule deer. Water requirements of the white-tailed deer are also comparable.

Elk

The Rocky Mountain elk is one of six subspecies of elk in North America and is the only elk species that remains in Wyoming. Scattered populations of the Rocky Mountain elk are located in selected areas of Carbon County. Available seasonal range maps indicate that Rocky Mountain elk are predominantly found in the following areas of the County:

- northwest Carbon County near Lamont,
- the Shirley Mountain basin,
- south, west and northwest of Rawlins,
- east of Encampment and Riverside, as well as,
- southwest of Encampment and the adjoining Sierra Madre area.

Elk tend to locate in areas that support food and water requirements, as well as provide heavier security cover. Elk consume grasses, forbs, and woody browse; however, their preference seems to be various grass species. Heavier security cover areas typically include dense forested areas and thick brush where elk can hide.

Rocky Mountain elk are migratory animals. Most Rocky Mountain elk migrate to higher elevations in the summer months; many of these areas are situated within the Medicine Bow National Forest. During the winter, elk seek wooded and brushy areas in lower elevation areas that contain south and southwest-facing slopes. The seasonal movement of the elk is largely prompted by snow conditions. Hard-packed snow restricts elk from reaching buried food sources. Elk typically avoid areas where snow is greater than 18 inches in depth even though elk can move through snow up to three feet in depth (Wyoming Game and Fish Department, 1992).

Between April to mid-June, elk primarily seeks a wide variety of grasses on transitional range areas. With the beginning of summer, elk tend to remain in a summer range where they will stay for about four months. As grasses dry and reduce in protein, elk supplement their grass consumption with forbs and sedges (Wyoming Game and Fish Department, 1992).

With the close of summer, elk return to winter range areas and graze on transitional ranges until the end of December. Such habitats frequently include timber stands of Douglas fir, aspen, and lodgepole pine. As forbs lose their succulence, elk shift their consumption to dry grasses and browse (leaves, stems, and buds of woody plants). Snow conditions occasionally limit the availability of grass. When this occurs, elk will usually seek shrubs. If snow depth limits the availability of shrubs, elk diets will incorporate aspen, conifers, sagebrush, willow, and other taller browse into their diets (Wyoming Game and Fish Department, 1992).

Water sources are usually located within 0.25 to 0.50 mile of grazing areas. The proximity of the surface water sources becomes more important when elk calves nurse their young. During the winter, snow provides moisture requirements when surface water is not available (Wyoming Game and Fish Department, 1992).

Moose

Moose are found in selected areas of Carbon County. Most moose are found south of Interstate 80 in portions of the Platte Valley and the adjoining Medicine Bow National Forest.

Moose prefer a variety of habitats. These habitats include coniferous and deciduous forests, shrublands, riparian areas, agricultural croplands, and moist mountain meadows (Wyoming Game and Fish Department, 1995).

Between 1963 and 1967, Houston evaluated about 6,000 observations of moose occurrences in the vicinity of Jackson, Wyoming during six seasonal periods. This study indicated that the willow species received about 60 percent of all consumption throughout the year. Upland spruce/fir, lodgepole pine, and aspen forest areas represented approximately 19 percent of total annual vegetative consumption. The remaining consumption of vegetation primarily included sagebrush and bitterbrush from sagebrush and grassland areas (Houston, 1968).

Big Horn Sheep

Big horn sheep are found in selected upland areas of Carbon County. Available seasonal range maps indicate that bighorn sheep are primarily found in the following areas within Carbon County:

- Seminoe Mountains,
- Ferris Mountains, as well as,
- Along the Platte River drainage between Bennett Peak and the Colorado border.

Bighorn sheep prefer areas that contain rocky terrain, open habitat that provides a higher degree of visibility, steeper slopes, southern exposure, well-established migration corridors to seasonal ranges, and snow-free areas during the winter. Rocky terrain, steeper slopes, and visibility are the more important habitat requirements because big horn sheep are primarily concerned with the availability of an escape route and the ability to see predators. Forested areas that are adjacent to feeding grounds are used for resting, thermal cover, and hiding cover (Cook, Arnett, Irwin, and Lindzey, 1989).

Sheep lamb during the months of May and June. Lambing areas are usually within 0.5 mile from a source of surface water and located away from potential sources of harassment, e.g., people, livestock, and predators.

Winter range areas are situated on south and east-facing slopes, and usually kept clear of snow. Bighorn sheep tend to move in snow depths less than 18 inches. Greater snow depths hamper sheep movements, as well as the availability of forage.

Upland grasses are the primary component of the big horn sheep's diet. The greatest consumption of grasses (approximately 85 percent) occurs in the summer when new grasses are available. Browse comprises the remainder of the summer diet. In the winter months, the consumption of grasses decreases to about 55 percent of the big horn sheep's diet. More browse is incorporated into the winter diet with the decreased availability of grasses.

Surface water sources are typically located within two miles of general habitat areas. During lambing season, lambs are generally kept within 0.5 of available water sources.

Mountain Lion

The mountain lion inhabits selected areas of Carbon County and is rarely seen by most residents. Preferred habitats include coniferous and deciduous forests, shrublands, rocky cliffs and ledges, and higher elevation meadows (Wyoming Game and Fish Department, 1995) where there are populations of mule deer or white-tailed deer (Dixon, 1982).

The seasonal movement of mountain lions generally reflects the pattern of mule or white-tailed deer, which represent 60 to 75 percent of their diet. The remaining 25 to 40 percent of the mountain lion diet consists of elk, grasses and other vegetation, porcupines, and other smaller mammals. Depending upon the availability of its regular diet preferences, mountain lions will sometimes kill livestock.

Because of their affinity to deer populations, mountain lions tend to move to higher elevations of the County in the summer months. During the fall and winter months, mountain lions inhabit lower elevations.

Black Bear

Black bear inhabit Carbon County's Snowy Range area and the Sierra Madre. Black bear are found in coniferous and deciduous forests, riparian areas, and moist meadow areas at higher elevations (Wyoming Game and Fish Department, 1995). Suitable forest habitats provide escape cover, protection from inclement weather, and winter dens. Meadows are preferred spring foraging areas. Moist meadows and riparian areas provide important herbaceous foods. Creek bottoms, as well as seral and climax stages of spruce and fir trees, become important in the late fall (Wyoming Game and Fish Department, 1992).

Black bears are omnivores and eat a variety of foods. Their diet typically includes grasses, forbs, rotted meats, fish, insects, fruits and berries, nuts and tree seeds.

The home range of black bears varies with season, the availability of food, the age and sex of the animal, and whether a female has cubs. The annual home range of black bears ranges between five and 45 square miles. In the summer months, home ranches decrease to 25 to 50 percent of the annual home range (Wyoming Game and Fish Department, 1992).

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Crucial Winter Range for Big Game Animals

One of the more important criteria for federal and State wildlife managers in Wyoming are land areas that are designated as "crucial winter range". This designation is one of six seasonal wildlife range classifications recognized and used by the Wyoming Game and Fish Department, the Wyoming State Land Board, the U.S. Bureau of Land Management, the U.S. Forest Service (Regions 2 and 4), the U.S. Fish and Wildlife Service, and the U.S. Natural Resource Conservation Service.

Background

Prior to 1987, wildlife resource managers from federal and State agencies in Wyoming were using different, and sometimes conflicting, seasonal range designations. The situation led to confusion among several agencies and constrained the ability to exchange resource information.

In response to the situation, the Wildlife Society, comprised of professional wildlife biologists, formed a committee between 1984 and 1986 to discuss, address, and ultimately establish seasonal wildlife range definitions that could be used by all wildlife resource managers in the State. However, in 1989, the Wildlife Society was requested by the U.S. Bureau of Land Management and the Wyoming Game and Fish Department to again review existing definitions. A new committee of the Wildlife Society responded to the request and gave particular attention to concerns regarding crucial and parturition habitat and the additional quantification of definitions. In July 1990, a final set of recommended revisions to the seasonal wildlife range designations was completed and distributed to all wildlife resource management agencies in Wyoming.

Significance of Crucial Winter Range Definition to Future Land Use

Crucial range refers to: *"…any particular range or habitat component (often winter or winter/year long range in Wyoming), but describes that component which is the determining factor in a population's ability to maintain and reproduce itself at a certain level (theoretically at or above the WGFD population objective) over the long term"* (The Wildlife Society, 1990).

Wyoming Game and Fish Department representatives indicate that crucial winter range areas are significant to sustaining big animal populations in Carbon County and other counties in the State. Crucial winter range areas, in essence, represent the habitat areas where big game animals move to during severe winter conditions. Consequently, big game animals are highly dependent upon these areas for long-term survival.

Using the new standardized definitions, the Wyoming Game and Fish Department completed the mapping of all seasonal wildlife range areas for big game animals in 1988. The maps prepared for Carbon County include polygons on larger scale maps that identify different types of seasonal ranges in geographical areas that include State, County, and privately owned lands. Some limited revisions have been made to the original polygon areas; however, such revisions have been limited even though State wildlife biologists regularly observe big game animals in the field.

Opportunity to Conserve Crucial Winter Range Areas for Big Game Animals

While some County residents, who are familiar with one or more parts of the County, might disagree with the boundaries of a given crucial winter range area, few residents would deny the enjoyment gained from the presence of big game animals in the County. Big game animals are clearly enjoyed for both hunting and the opportunity to view these animals in their natural habitat.

At the same time, ranchers are also more than cognizant of the conflicts between cattle ranching and big game animal habitat. Rural residents of the County regularly lose trees and shrubs unless they are adequately fenced.

Carbon County believes that future land use decisions, e.g., rezoning applications, should consider the impact of proposed land uses upon crucial winter range habitat for big game animals. At the same time, it is important that such considerations do not undermine individual property rights of County residents.

NONGAME WILDLIFE RESOURCES

General

Various nongame wildlife species are found in Carbon County because of the diversity of habitats that are available in the County. Several mammals and bird species, which are of special concern to the Wyoming Game and Fish Department, are identified in the following paragraphs. These species include mammals and birds whose population is:

- greatly restricted,
- declining, or its status is unknown,
- experiencing significant losses, and/or
- vulnerable to potential environmental stresses.

Mammals

Mammal species in Carbon County, which are of special concern to the Wyoming Game and Fish Department, include black-footed ferrets, dwarf shrews, swift foxes, water voles as well as 10 species of bats.

Black-Footed Ferret

The black-footed ferret has been rarely observed in Carbon County. The habitat of this weasel-like mammal includes shrublands that are dominated by sagebrush, bitterbrush, mountain mahogany, chokecherry, serviceberry, and/or greasewood. The black-footed ferret is also found in open expanses of grasslands that are primarily characterized by flue grama, buffalo grass, wheatgrass, gluestem, and silver sagebrush (Wyoming Game and Fish Department, 1995).

The ferret is a predator that kills and eats prairie dogs, and occasionally mice. Since the ferret lives in prairie dog borrows, the ferret cannot survive for extended periods without prairie dogs.

The Wyoming Game and Fish Department regards the Shirley Basin as an important management area for this specie in the foreseeable future. A reintroduction site for the black-footed ferret is located in this area. Even though no ferrets have been released in this area during the 1995-1996 period, the Wyoming Game and Fish Department believes that the Shirley Basin represents an important link to the long-term survival of the ferret (Wichers, 1997).

Swift Fox

The swift fox has rarely been observed in Carbon County. The habitat for this mammal is primarily located in grasslands. However, the swift fox can also be found in sagebrush grasslands, agricultural areas, irrigated native meadows, as well as roadside and railroad banks (Wichers, 1997).

The black-ferret reintroduction site in the Shirley Basin also supports one of the higher densities of swift fox in the State of Wyoming. As a result, the Wyoming Game and Fish Department believes that Carbon County contains important swift fox habitat. Further, the Department believes that future special management efforts will be required to sustain this specie (Wichers, 1997).

Dwarf Shrew, Water Vole, and Vagrant Shrew

The population and distribution of these three species in Carbon County is presently unknown. The Wyoming Game and Fish Department indicates that field surveys are needed to determine the status of these species, as well as any possible management strategies (Wichers, 1997).

The habitat of the dwarf shrew comprises coniferous forests, aspen stands, mountain foothills and shrublands, alpine areas and talus, and rocky areas. The water vole is found in alpine and subalpine meadows that are associated with water and mountain foothill grasslands (adjacent to streams). Riparian and marsh areas, moist meadow grasslands, and bogs provide habitat for the vagrant shrew (Wichers, 1997).

Bats

Ten species of bat occur in Carbon County. These bat species are found in a variety of habitats such as forests, buildings, caves, and abandoned mines.

The Wyoming Game and Fish Department believes that these species will require future protection and management (Wichers, 1997).

Birds

General

A wide variety of bird species occur in Carbon County. The bird species that are of special concern to the Wyoming Game and Fish Department are summarized in Table 6-5. With the exception of the peregrine falcon, this list of birds is limited to bird species that have been recorded to nest in Carbon County.

Other species of special concern may occur in Carbon County, but may only use habitats in the County for feeding or migration stop-overs. It is also possible that the summary of birds of special concern may be incomplete since specific field observations of other species have not been undertaken by the Wyoming Game and Fish Department (Wichers, 1997).

TABLE 6-5
BIRD SPECIES WITHIN CARBON COUNTY
OF SPECIAL CONCERN TO THE WYOMING GAME & FISH DEPARTMENT

Bird Species	General Habitat
Bald Eagle	Nest in riparian habitat, e.g., cottonwood trees, along North Platte River
Northern goshawk	Coniferous forests for nesting, but will forage in variety of habitats
Ferruginous hawk	Cottonwood riparian areas, basin prairie shrubland, mountain foothill grasslands, and rocky outcrops
Peregrine falcon	Cliffs for nesting
Boreal owl	Coniferous and mixed coniferous/deciduous forests
Western grebes	Marshes and lakes
American white pelican	Rivers, lakes, or marshes, e.g., bird island in Pathfinder Reservoir
American bittern	Marshes and lakes
Snowy egret	Marshes and lakes
Black-crowned night heron	Marshes and lakes
Great blue heron	Nest in tree colonies; found along rivers and lakes
Forster's tern	Marshes and aquatic areas
Black tern	Marshes and aquatic areas
Mountain plover	Short-grass, mid-grass, and sagebrush grasslands
Long-billed curlew	Sagebrush and moist meadow grasslands, mountain and irrigated native meadows, and aquatic areas
Sage Grouse	Sagebrush
Lewis' woodpecker	Ponderosa pine, pine-juniper, and other coniferous forests, aspen stands, and cottonwood riparian areas under 9,000 feet
Veery	Aspen stands, cottonwood riparian areas, and coniferous forests below 9,000 feet
American redstarts	Cottonwood riparian and riparian shrub habitats
Common yellowthroats	Willows and marshes below 8,000 feet
McCown's longspurs	Foothill grasslands, basin prairie shrublands, and agricultural areas

Source: Wichers, 1997; Hiatt, 1997

Sage Grouse

One of the birds of special concern to State wildlife biologists, who are based in Carbon County, is the sage grouse. State biologists have documented and mapped sage grouse habitat areas in Carbon County (Hiatt, 1997).

Sage grouse occupy most sagebrush habitats. Sage grouse are dependent upon sagebrush and related riparian areas for year-round habitat. While sagebrush is necessary year round, the characteristics of useful sagebrush stands vary. The usefulness of sagebrush stands is dependent upon its variable use for breeding, nesting, brood rearing, or wintering area (Loose, 1997).

"From November through March, sage grouse are limited to habitat with greater than 20% sagebrush cover for shelter and winter diet. Sage grouse can be widely dispersed over a wintering area but concentrate in areas with exposed sagebrush as snow depth increases" (Loose, 1997).

"From late February through April, sage grouse gather on breeding grounds, or leks, which are used year after year. Leks vary in size from a few hundred feet to several acres. These strutting grounds are generally open areas surrounded by dense sagebrush with 20 to 40% cover. Most nesting occurs in this dense sagebrush within two to four miles of the lek" (Loose, 1997).

Food habitats of the sage grouse are seasonal, but big sagebrush is the primary source of food throughout the year. During the spring and summer months, forbs and insects become important. Insect protein is important to young chicks. The sage grouse diet shifts to more sagebrush as the fall progresses (Loose, 1997).

AQUATIC RESOURCES

Game and Nongame Fish

The aquatic resource that is most familiar to Carbon County residents is the fish that inhabits local creeks, streams, rivers, and man-made impoundments. In Wyoming, there are 49 extant native fish (Table 6-6) and 27 established nonnative fish (Table 6-7) species. Most of these species occur in Carbon County.

An existing fisheries data base, which was developed and currently maintained by the Wyoming Game and Fish Department, indicates that there approximately 903 creeks, streams, rivers, and man-made impoundments in the County that provide habitat for native and nongame fish species. The database also identifies the type of fish that occur in each water body, the species of fish being managed, and provides a classification that indicates the relative importance of each water body to overall trout fishing opportunities.

While game fishing is an important form of recreation to both residents and visitors of Carbon County, the Wyoming Game and Fish Department indicates that it is modifying and updating its stream classification system. This update, which is to be completed in the spring of 1998, will be more oriented to habitat conditions and will apparently reflect various environmental indicators.

Creel limits and the closure of selected water bodies to fishing represent the primary resource management tools that are used by the Wyoming Game and Fish Department. In addition, the reintroduction of selected fish species to specific water bodies occasionally made by the Department to enhance fishery habitat and recreational fishing opportunities.

During the summer of 1997, for example, the Wyoming Game and Fish Department caught Colorado River cutthroat trout on the Roaring Fork of the Little Snake River in the Sierra Madre Mountains. This effort was made to enable the reintroduction of this specie to the higher-altitude areas of Muddy Creek, which historically was part of its habitat range (Rawlins Daily Times, 1997).

TABLE 6-6 NATIVE FISH SPECIES OF WYOMING		
Common Name	**Resource Use**	**Occurrence in Carbon County**
Arctic grayling	Game	No
Bigmouth shiner	Nongame	Yes
Black bullhead	Game	Yes
Bluehead sucker	Nongame	Yes
Brassy minnow	Nongame	Yes
Burbot	Game	Yes
Central stoneroller	Nongame	No
Channel catfish	Game	Yes
Common shiner	Nongame	Yes
Creek chub	Nongame	Yes
Cutthroat trout	Game	Yes
Fathead minnow	Nongame	Yes
Finescale dace	Nongame	Yes
Flannelmouth sucker	Nongame	Yes
Flathead chub	Nongame	Yes
Goldeye	Nongame	Yes
Horneyhead chub	Nongame	Yes
Iowa darter	Nongame	Yes
Johnny darter	Nongame	Yes
Lake chub	Nongame	Yes
Leatherside chub	Nongame	Yes
Longnose dace	Nongame	Yes
Longnose sucker	Nongame	Yes
Mottled sculpin	Nongame	Yes
Mountain sucker	Nongame	Yes
Mountain whitefish	Game	Yes
Orangethroat darter	Nongame	Yes
Paiute sculpin	Nongame	Yes
Pearl dace	Nongame	No
Plains killifish	Nongame	Yes
Plains minnow	Nongame	Yes
Plains topminnow	Nongame	Yes
Quillback	Nongame	Yes
Red shiner	Nongame	Yes
Redside shiner	Nongame	Yes
River carpsucker	Nongame	Yes
Roundtail chub	Nongame	Yes
Sand shiner	Nongame	Yes
Sauger	Game	Yes
Shorthead redhorse	Nongame	No
Shovelnose sturgeon	Game	Yes
Speckled dace	Nongame	Yes
Stonecat	Game	Yes
Sturgeon chub	Nongame	Yes
Suckermouth minnow	Nongame	Yes
Utah chub	Nongame	Yes
Utah sucker	Nongame	No
Western silvery minnow	Nongame	No
White sucker	Nongame	Yes

Source: Wyoming Game and Fish Department, 1997

TABLE 6-7 NONNATIVE FISH SPECIES OF WYOMING		
Common Name	**Resource Use**	**Occurrence in Carbon County**
Black crappie	Game	Yes
Bluegill	Game	Yes
Brook trout	Game	Yes
Brown trout	Game	Yes
Common carp	Nongame	Yes
Emerald shiner	Nongame	Yes
Freshwater drum	Game	No
Gizzard shad	Nongame	Yes
Golden shiner	Nongame	Yes
Golden trout	Game	Yes
Goldfish	Nongame	Yes
Grass carp	Nongame	Yes
Green sunfish	Game	Yes
Kokanee (lacustrine sockeye salmon)	Game	Yes
Lake trout	Game	Yes
Largemouth bass	Game	Yes
Northern pike	Game	Yes
Ohrid trout	Game	Yes
Pumpkinseed	Game	Yes
Rainbow trout	Game	Yes
Rock bass	Game	Yes
Smallmouth bass	Game	Yes
Spottail shiner	Nongame	Yes
Walleye	Game	Yes
Western mosquitofish	Nongame	No
White crappie	Game	Yes
Yellow perch	Game	Yes

Source: Wyoming Game and Fish Department, 1996

FUTURE CONSIDERATION OF THE ENVIRONMENT

Numerous natural resources are present in Carbon County. Residents of the County enjoy a unique relationship with these resources because:

- Various outdoor recreational opportunities take place in forested and rangeland areas, as well as rivers and streams within the County.
- Many residents regularly view scenic vistas and wildlife during normal working hours, from their homes, or when they travel within the County.
- The County's visitor industry is dependent upon the exploitation and conservation of these resources.

In this context, the County believes that the physical and biological resources of the regional environment should be used and conserved wisely. At the same time, the conservation of these resources should be balanced with social and economic needs of Carbon County residents who serve as both stewards and users of the land and natural resources.

While traditional zoning frequently does not reflect resource management considerations, Carbon County believes that it is important to conserve the crucial winter range of big game animals, as well as the surface water quality of local streams. In this context, the County Planning Commission desires to integrate the consideration of crucial winter range areas for big game animals in its future land management decisions.

Similarly, a reasonable setback will be established for all structural development that occurs adjacent to surface water bodies such as creeks, streams, ponds and lakes, and natural impoundments. This consideration, which will be applicable to all residential, commercial, and industrial land uses, will consider flood protection, water quality, public recreation, and aquatic habitat.

Carbon County will also evaluate future options for the long-term conservation of irrigated lands in the Little Snake River and Upper North Platte River basins.