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Physical and Human Geography of the Henry's Fork Watershed

Abstract

The 8444-km² Henry's Fork watershed lies in eastern Idaho and western Wyoming. It is bounded by the Continental Divide to the north, the Yellowstone Plateau and Teton Range to the east, the Big Hole Mountains to the south, and the Snake River Plain to the west. The Upper Henry's, Lower Henry's and Teton hydrologic units comprise the watershed, whose major streams are the Henry's (North) Fork of the Snake, Teton and Fall rivers. Recently formed volcanic features, including the Snake River Plain, Island Park Caldera, and Madison and Pitchstone plateaus, dominate the geology. Mean annual temperature and precipitation, respectively, range from about 5.3° C and 30 cm at the lowest elevations (1400 m) to less than 1° C and over 100 cm at the highest elevations (3300 m). Pine, fir and spruce forests dominate upland areas; sagebrush steppe and cultivated agricultural land are found at lower elevations. Native people used the area seasonally for fishing, hunting and gathering. The area was first settled by Euro-Americans in the mid- to late 19th century and remains sparsely populated. The watershed boundary roughly coincides with that encompassing the Idaho counties of Fremont, Madison and Teton, where jobs are provided primarily by agriculture and other natural-resource-related occupations, construction, service industries and government. About 50 percent of the watershed is federally owned, and forest, range and agriculture account for about 95 percent of land use. The watershed is well known for seed potato production and outstanding outdoor recreational opportunities, most notably fishing, snowmobiling, and skiing.

Key words: Henry's Fork, Teton, Snake River, watershed, geography, economics

Introduction

The Henry's Fork of the Snake River has been well known throughout the country for its outstanding trout fishing opportunities since the 1880s. The rich agricultural land along the river's lower reaches is equally well known to the agricultural community as the world's largest seed-potato production area (Van Kirk and Griffin 1997). The cultural and economic significance of angling, on the one hand, and irrigated agriculture, on the other, have made the Henry's Fork watershed a natural battleground for conflicts over water management issues (Van Kirk and Griffin 1997). Yellowstone and Grand Teton national parks flank the watershed's east side, further adding to the complexity of natural resource management in the area. Over the past two decades, water and other natural resource management issues in the watershed have received national attention, both for the intensity of conflicts over them and for the eventual success of collaborative watershed research and management efforts. In natural resource management circles, the watershed is now as famous for its successful watershed council as for fishing or potato production (Van Kirk and Griffin 1997, Weber this issue). The contents of this issue illustrate the

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importance of research in collaborative watershed management and also, the importance of the Henry's Fork watershed as a laboratory in which aquatic resource research of regional and national significance has been conducted over the past three decades.

This paper serves as a study area description for the other papers that appear in this issue. We begin with an explanation of place name conventions used in this issue before presenting major features of physical and human geography in the watershed. Except for a few detailed aspects of study areas appearing in some of the individual papers in this issue, all place names mentioned in the other papers appear on the maps in this paper.

River Name Conventions

The Henry's Fork of the Snake River and Henry's Lake were named after Andrew Henry, whose Missouri Fur Company expedition arrived in the watershed in 1810 and spent the winter of 1810-1811 along the river southwest of present-day St. Anthony (Fig. 1) (Brooks 1986, Green 1990). Subsequent explorers and trappers referred to the two major forks of the Snake River as "Henry's Fork" and "Lewis' Fork" (e.g., Russell 1965). The modern convention of omitting apostrophes from possessive place names to minimize the potential for map symbol misinterpretation has resulted in the official U.S. Geological Survey (USGS) designation of "Henrys Fork," which is how the river name appears on most maps and in many publications, particularly in the scientific literature. We have chosen to use the apostrophe in this journal, in part because many local organizations and businesses bearing the river's name use the apostrophe, e.g., Henry's Fork Watershed Council, and in part because the apostrophe correctly indicates the possessive origin of the name. The exception to this convention is that the titles of literature cited in the journal are spelled as they were originally published, regardless of the convention used.

Although the Henry's Fork name has been retained for the northern of the two forks of the Snake River, Lewis' Fork became known as simply the "Snake River," which is its official designation. Local usage often refers to the Henry's Fork as the "North Fork" of the Snake River and to the Snake River between Palisades Reservoir and the Henry's Fork confluence as the "South Fork" (Fig. 2). The river upstream of Palisades Reservoir is always referred to as the "Snake River," its official name. Although generally restricted to colloquial usage, the North Fork nomenclature was used frequently in Idaho Department of Fish and Game and other government documents published prior to 1980 (see Van Kirk this issue).

Two other river name conventions deserve mention because of historical discrepancies in usage. The first is "Fall" versus "Falls" as the name of the major tributary joining the Henry's Fork between Ashton and St. Anthony (Fig. 1). Although there has been debate over the original name of this river, the official USGS designation for many years was "Falls River," contrary to local eastern Idaho usage. Recently, a petition to change the name to "Fall River" was accepted, and the river now officially bears the singular name. We will use the new convention in this journal, although most maps and documents existing in the literature use the older plural convention.

The second convention that warrants mention is the use of "Henry's Lake Outlet" as the name of the stream flowing out of Henry's Lake (Fig. 3). Official USGS designation of this stream is "Henrys Fork," and because no streams flowing into Henry's Lake bear the Henry's Fork name, this nomenclature implies that Henry's Lake is the ultimate source of the Henry's

Figure 1. *Shaded relief map of the Henry's Fork watershed showing major physiographic features. The solid white line indicates the watershed boundary.*

Fork. Although perusal of maps suggests this to be the case, the hydrologic source of the Henry's Fork in terms of maximum annual discharge is Big Springs, which lies about 15 km to the southeast of the lake (Fig. 3). If the usual convention of assigning the name of a river at each confluence to the fork

Figure 2. *Major hydrologic features of the Henry's Fork region, showing the three USGS hydrologic cataloging units comprising the Henry's Fork watershed (UH = Upper Henry's, LH = Lower Henry's, T = Teton).*

carrying the most water were followed in this case, Big Springs would be designated as the headwaters of the Henry's Fork. In addition to the apparent error in assigning the Henry's Fork name to the outlet stream of Henry's Lake, the large (about 5.5 m^3/s discharge) stream originating at Big Springs is not officially named. In this issue, we will follow local usage and refer to the stream flowing out of Henry's Lake as "Henry's Lake Outlet." We will consider the headwaters of the Henry's Fork to be the confluence of Henry's Lake Outlet and the stream originating at Big Springs. The 3 km of

Figure 3. *Major water bodies and research sites in the upper Henry's and Fall River subwatersheds.*

stream between Big Springs and the Henry's Lake Outlet remains unnamed but is generally referred to as simply "Big Springs." At least one author (Anderson 1996) has referred to this stream as "Big Springs Creek," but we will not adopt this convention.

Physical Geography

The 8444-km^2 Henry's Fork watershed is located in eastern Idaho and western Wyoming (Fig. 2). It is bounded by the Continental Divide to the north, the Yellowstone Plateau and Teton Range to the east, the Big Hole Mountains to the south, and the Snake River Plain to the west (Fig. 1). Elevations range from 1400 m at the southwest corner of the watershed to over 3300 m along the crest of the Teton Range. Major mountain ranges include the Teton, Big Hole, Centennial and Henry's Lake mountains (Fig. 1). These mountain ranges are the oldest geologic features in the watershed, which is otherwise dominated by volcanic formations of more recent origin.

The volcanic features present in the Henry's Fork watershed were created between 4 million and about 600,000 years ago as a "hot spot" of volcanism moved northeastward through the region (Hackett and Bonnichsen 1994). This hot spot now lies under Yellowstone National Park, just to the east of the watershed. The oldest volcanic formations in the watershed are those associated with the Snake River

Plain, an 80- to 110-km wide crescent of lava covering most of southern Idaho. The Island Park region lies at the transition between the basalts of the Snake River Plain and the more recent rhyolite flows of the Yellowstone Plateau (Christiansen 1982, Christiansen and Embree 1987). The Island Park Caldera (Fig. 1) consists of three smaller calderas formed by cycles of volcanism occurring between 2 million and 600,000 years ago as the hot spot traveled northeast through the Island Park region. The Madison and Pitchstone plateaus on the northeastern edge of the watershed were formed by rhyolite flows that erupted from the Yellowstone hot spot about 600,000 years ago. Benjamin (this issue) provides a more detailed discussion of the geology of the Island Park region and its hydrologic implications.

Because of the young age and volcanic nature of its geology, the Henry's Fork watershed is not characterized by the broad glacial valleys and associated alluvial floodplain river systems that typify most other watersheds in the Rocky Mountains. Rather, broad, flat plateaus and plains characterize the landscape, which has a low drainage network density. Most streams draining the areas of volcanic origin have a substantial degree of groundwater influence and tend to have high width-to-depth ratios, low gradients and limited floodplain development (Anderson 1996, Benjamin 1997, Gregory 1997, Gregory 1998, Gregory and Van Kirk 1998, Gregory 1999). However, two small examples of alluvial valleys occur in the northern part of the watershed. The valley that contains Henry's Lake and its outlet lies in a narrow fold between the Centennial and Henry's Lake mountains, and Shotgun Valley lies along the southern flank of the Centennial Mountains (Fig. 1). The only large mountain valley that occurs in the watershed is the Teton Valley, which lies between the Teton Range and Big Hole Mountains (Fig. 1). Tributaries to the Teton River draining these mountains are more typical of Rocky Mountain alluvial streams than those in the rest of the watershed.

The Henry's Fork watershed consists of three USGS hydrologic cataloging units, the Upper Henry's, Lower Henry's and Teton, each of which comprise about a third of the watershed's area (Fig. 2 and Table 1). The Upper Henry's hydrologic unit or subwatershed consists of the Henry's Fork and its tributaries upstream of Ashton Reservoir (Fig. 3). The Lower Henry's subwatershed contains the river and its tributaries downstream to its confluence with the Snake River and essentially is the watershed of the Fall River plus the mainstem Henry's Fork below Ashton. The third subwatershed contains the Teton River and its tributaries.

Table 1. *Hydrologic characteristics of the Henry's Fork watershed and subwatersheds. Data from U.S. Geological Survey, U.S. Environmental Protection Agency and Van Kirk (1999).*

	Subwatershed (USGS cataloging unit)			
	Upper Henry's	Lower Henry's	Teton	Watershed Total
USGS cataloging number	17040202	17040203	17040204	
Area (km^2)	2,823	2,694	2,927	8,444
Perennial stream length (km)	845	885	1,068	2,798
Intermittent stream length (km)	1,323	497	1,458	3,278
Total stream length (km)	2,168	1,382	2,526	6,076
Number of lakes and reservoirs	77	102	37	216
Lake and reservoir surface area (ha)	6,268	936	140	7,344
Mean annual discharge (10^6 m^3)	1,360	1,875	748	1,875

The climate of the Henry's Fork watershed is arid to semi-arid, except at the highest elevations, and is characterized by subfreezing winters and cool summers (Table 2, Figs. 4 and 5). Mean annual temperature and precipitation, respectively, range from about 5.3 °C and 30 cm at the lowest elevations to less than 1 °C and over 100 cm at the highest elevations. Precipitation is nearly uniformly distributed throughout the year at the lowest elevations but is characterized by a large early-winter peak at the higher elevations (Fig. 4). May and June are the wettest months at lower elevations, whereas November, December, and January are the wettest months in the mountains. The vast majority of discharge in the watershed's streams is derived from snowfall at elevations greater than 1900 m.

The higher elevations of the Henry's Fork watershed lie in the Middle Rockies ecoregion; the lower elevations lie in the Snake River Basin/High Desert ecoregion (Omernik 1987). Prior to the development of cultivated agriculture in the watershed, elevations below 1800 m were primarily grassland and shrub steppes. Dominant species included wheatgrasses (*Agropyron* spp.), needlegrasses (*Stipa* spp.), Idaho fescue (*Festuca idahoensis*), big sagebrush (*Artemesia tridentata*), rabbit brushes (*Chrysothamnus* spp.), bitterbrush (*Purshia tridentata*) and serviceberry (*Amelanchier alnifolia*) (Marston and Anderson 1991). Cultivated cropland largely has replaced these native

Table 2. *Climatic data for stations in the Henry's Fork watershed. Data are means for the period 1961-1990 as reported by Idaho State Climate Services at the University of Idaho.*

Station	Elevation (m)	Mean Annual Temp. (°C)	Mean Annual Precip. (cm)
Ashton	1603	4.89	52.5
Driggs	1864	4.72	42.6
Island Park	1917	2.83	74.8
St. Anthony	1509	5.28	35.5

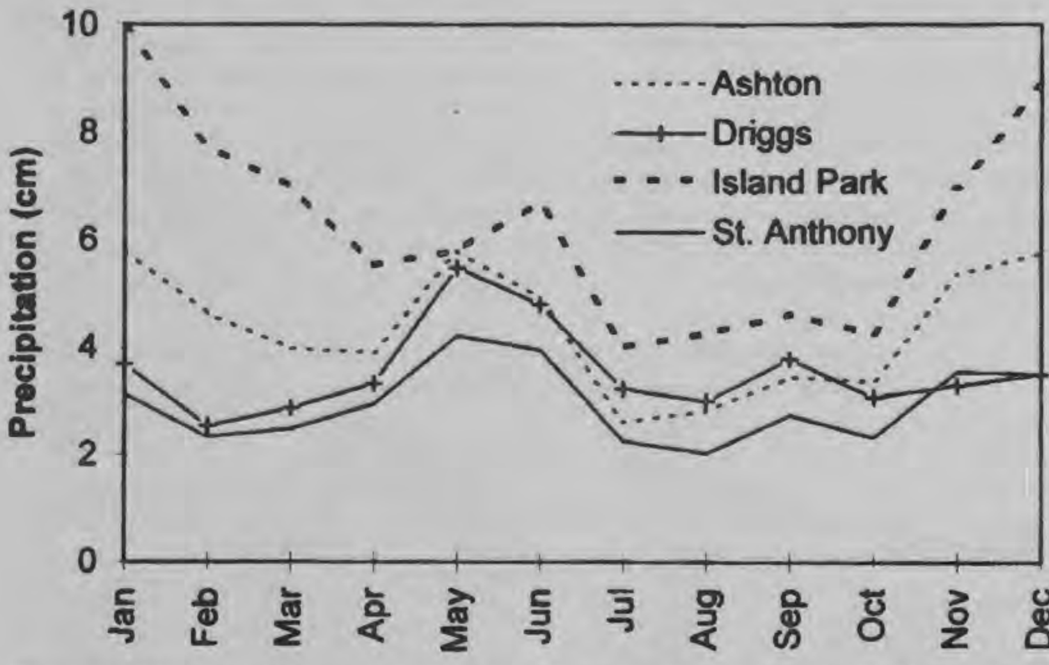

Figure 4. *Mean monthly precipitation at weather recording stations in the Henry's Fork watershed. Values are means for the period 1961-1990 as reported by Idaho State Climate Services at University of Idaho.*

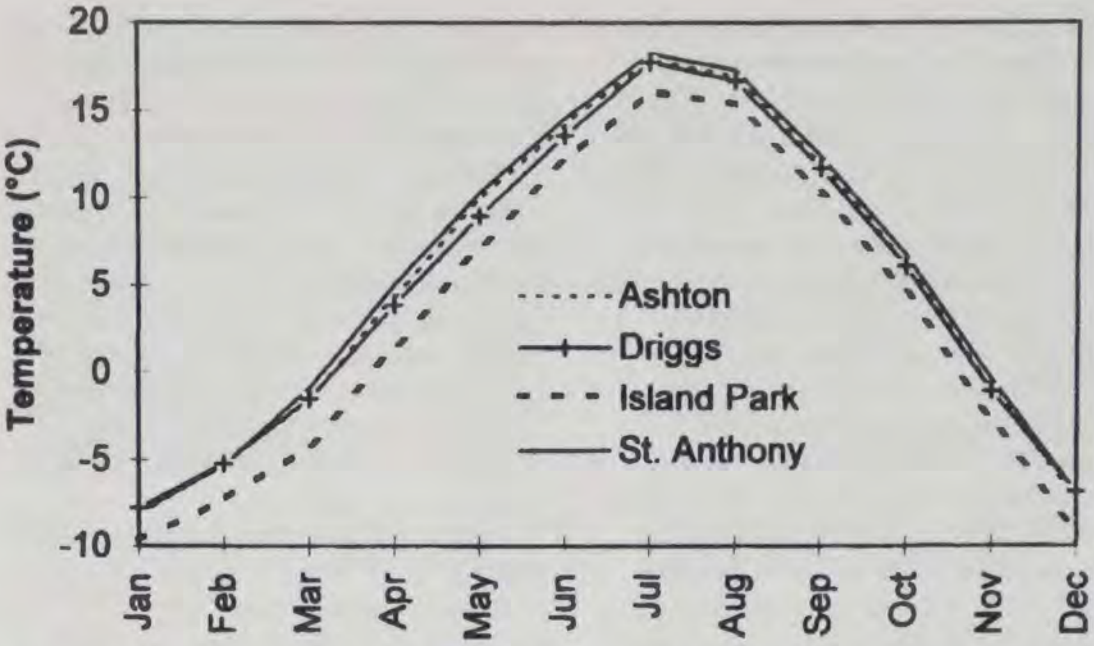

Figure 5. *Mean monthly temperatures at weather recording stations in the Henry's Fork watershed. Values are means for the period 1961-1990 as reported by Idaho State Climate Services at University of Idaho.*

grassland and steppe communities. At higher elevations, the steppes give way to Rocky Mountain juniper (*Juniperus scopulorum*), lodgepole pine (*Pinus contorta*) and Douglas fir (*Pseudotsuga menziesii*), with stands of aspen (*Populus tremuloides*) often occurring at the steppe-forest transition. Mixed forests of Engelmann spruce (*Picea engelmanni*) and subalpine fir (*Abies lasiocarpa*) occur at high elevations immediately below treeline. High alpine meadows occur in all of the watershed's mountain ranges. Riparian vegetation assemblages are dominated by sedges (*Carex* spp.) along spring-fed streams, willows (*Salix* spp.) along most other higher-elevation streams and cottonwoods (*Populus* spp.) along lower-elevation streams (Jankovsky-Jones and Bezzerides this issue).

Human Geography

The native inhabitants of the Henry's Fork watershed were various branches of the Shoshone people, including the Eastern Shoshone, Bannock, Lemhi and Tukuarika (Sheepeater) Indians. These native people were largely nomadic, spending the winter in the lower elevations of the Snake River Plain and traveling to the higher elevations seasonally to hunt, fish, gather roots and berries, and obtain obsidian from sources in and around what is now Yellowstone National Park (Brooks 1986, Green 1990). Other native people, including the Crow, Flathead, and Nez Perce were known to travel through the watershed occasionally. The first Euro-American to explore the Henry's Fork watershed is believed to be John Colter, a member of the Lewis and Clark expedition who left the group on its way back to Missouri and spent the next several years in the Yellowstone region. He spent the winter of 1807-08 in the Teton Valley. The watershed's first white resident was Richard Leigh, who settled in Teton Valley in 1860. Whereas Leigh made a living from hunting, trapping, and guiding, another early settler, Gilman Sawtell, was one of the first people to raise domestic cattle in the area and to profit from the region's prolific trout populations. Sawtell settled at Henry's Lake in 1868, and by 1877, when General Howard passed through the region in pursuit of Chief Joseph and the Nez Perce, Sawtell was operating a commercial trout fishery on the lake (Brooks 1986, Green 1990). The first sportfishing club in the watershed was established on Henry's Lake in 1888 by a group of businessmen from Pittsburgh, Pennsylvania, and by the turn of the century, the outstanding trout fishing opportunities of the Henry's Fork watershed were known around the country (Brooks 1986, Green 1990).The first people to raise crops in the watershed were Mormon farmers from Utah, who settled in the area near the confluence of the Henry's Fork and the Snake River in 1879 (Carter 1955). From there, they and other immigrants spread agriculture throughout the lower elevations of the watershed. Meanwhile, ranching and logging were increasing throughout the watershed, and expansion of rail lines from St. Anthony to Ashton, Island Park, and Victor shortly after the turn of the 20th century provided increased transportation support for these new natural-resource-based industries. Because of the aridity of the climate, irrigation was necessary to raise most crops, and farmers formed canal companies and irrigation districts, most of which were assisted by federal programs designed to promote agricultural development in the western U.S.

The first company to construct a major storage reservoir in the watershed was the North Fork Reservoir Company, an organization of farmers southwest of St. Anthony who completed a dam on Henry's Lake Outlet in 1923. The dam raised the level of the shallow, natural Henry's Lake about 5 meters to provide 111 million m^3 of storage. The Fremont-Madison Irrigation District was formed in 1935 and entered into a contract that year with the U.S. Bureau of Reclamation to construct storage reservoirs in the watershed. In 1939, Grassy Lake Dam on Fall River and the much larger Island Park Dam on the Henry's Fork were completed. These facilities are part of the Bureau of Reclamation's Minidoka Project, which irrigates agricultural land throughout the Snake River basin from the Twin Falls area upstream. Island Park Reservoir holds 167 million m^3 of storage, and its construction had major effects on the hydrology and fisheries of the upper Henry's Fork watershed (Benjamin and Van Kirk 1999, Van Kirk and Gamblin this issue).

A third large storage reservoir was completed in 1975 on the Teton River near the mouth of Teton Canyon northeast of Rexburg. However, on 5 June 1976, the dam failed, and the contents of its nearly-full reservoir—three times the volume of Island Park—poured out onto the plains below, killing 11 people, completely destroying the towns of Wilford and Sugar City, and causing significant damage in Rexburg (Reisner 1993). The Teton Dam collapse notwithstanding, irrigation accounts for over 99 percent of the surface and ground water consumed in the Henry's Fork watershed (Table 3), and agriculture dominates the landscape of the lower half of the watershed. The primary crops are potatoes and grain, and the area around Ashton is known as the world's largest seed-potato production area.

The Henry's Fork watershed boundary coincides roughly with that encompassing the Idaho counties of Fremont, Madison, and Teton (Fig. 6). A small portion of Teton County, Wyoming, lies at the far eastern edge of the watershed, and a small portion of Clark County, Idaho, lies in the northwestern corner. Small parts of Fremont and Madison counties lie outside of the watershed. The three primary counties have a combined population of 40,636, which is largely rural (Table 4). Nearly all of the increase in the watershed's population over the

Table 3. *Water use in the Henry's Fork watershed and subwatersheds. Figures are for 1995. Data from U.S. Geological Survey.*

	Subwatershed (cataloging unit)			
	Upper Henry's	Lower Henry's	Teton	Watershed Total
Irrigated land (ha)	20,555	18,685	53,327	92,567
Irrigated land (% of total)	7.3%	6.9%	18.2%	11.0%
Total groundwater withdrawals (m^3)	69,644	89,667	379,820	539,130
Total surface withdrawals (m^3)	486,360	673,690	879,520	1,742,570
Irrigation conveyance loss (m^3)	379,370	199,660	466,160	1,045,190
Reservoir evaporation (m^3)	9,905,300	752,450	0	10,657,750
Total consumptive use (m^3)	264,610	152,380	401,780	818,770
Irrigation use (% of total consumptive use)	99.96%	99.53%	99.59%	99.70%

Table 4. *Socioeconomic characteristics of counties in the Henry's Fork watershed. Unless noted otherwise, figures are for calendar year 1997. Data from Idaho Department of Commerce.*

	Fremont	Madison	Teton (ID)	Total
County seat	St. Anthony	Rexburg	Driggs	
Population	11,818	23,508	5,310	40,636
Population change (1990-1997)	8.1%	-0.7%	54.4%	6.8%
Rural population (1996)	73%	39.4%	100%	51.1%
Median house value ($, 1990)	46,200	68,700	59,000	NA
Crime rate (per 100,000)	1,373	2,500	1,426	2,061
Unemployment rate	8.0%	3.3%	4.8%	4.6%
Total employment (1996)	4,715	12,882	2,262	19,859
Employment by industry (1996)				
Farm	21.2%	7.1%	16.4%	11.5%
Private ag. service, forestry, etc.	5.5%	2.8%	3.5%	3.5%
Manufacturing	1.7%	10.3%	4.5%	7.6%
Construction	6.1%	4.0%	11.5%	5.4%
Wholesale	4.2%	7.2%	0.9%	5.8%
Retail	15.0%	18.2%	18.7%	17.5%
Service	16.8%	32.7%	20.0%	27.5%
Government	21.9%	11.7%	18.1%	14.9%
Other	7.6%	6%	6.4%	6.3%
Total personal income (million $)	170.0	312.0	73.0	555.0
Per capita income ($, 1996)	13,894	12,697	12,471	13,016
Mean earnings per job ($)	18,646	18,632	15,824	18,315
Number of farms	493	470	270	1,233
Total value of farm products (million $)	81.0	80.5	22.8	184.3
Total personal farm income (million $)	19.7	16.4	8.0	44.1

past decade has occurred in Teton County, which has one of the highest growth rates of any county in the country. Most of this growth is being fueled by its proximity to the resort town of Jackson, Wyoming, and by its own recreational offerings, including skiing at Grand Targhee resort just across the Wyoming state line east of Driggs. Agriculture and associated industries provide about 15 percent of the watershed's jobs, roughly equivalent to the number of jobs provided by government. The U.S. Forest Service is a major employer in Ashton, St. Anthony, and Driggs, a reflection of the large amount of federal land in the watershed (Table 5). About half of the watershed's

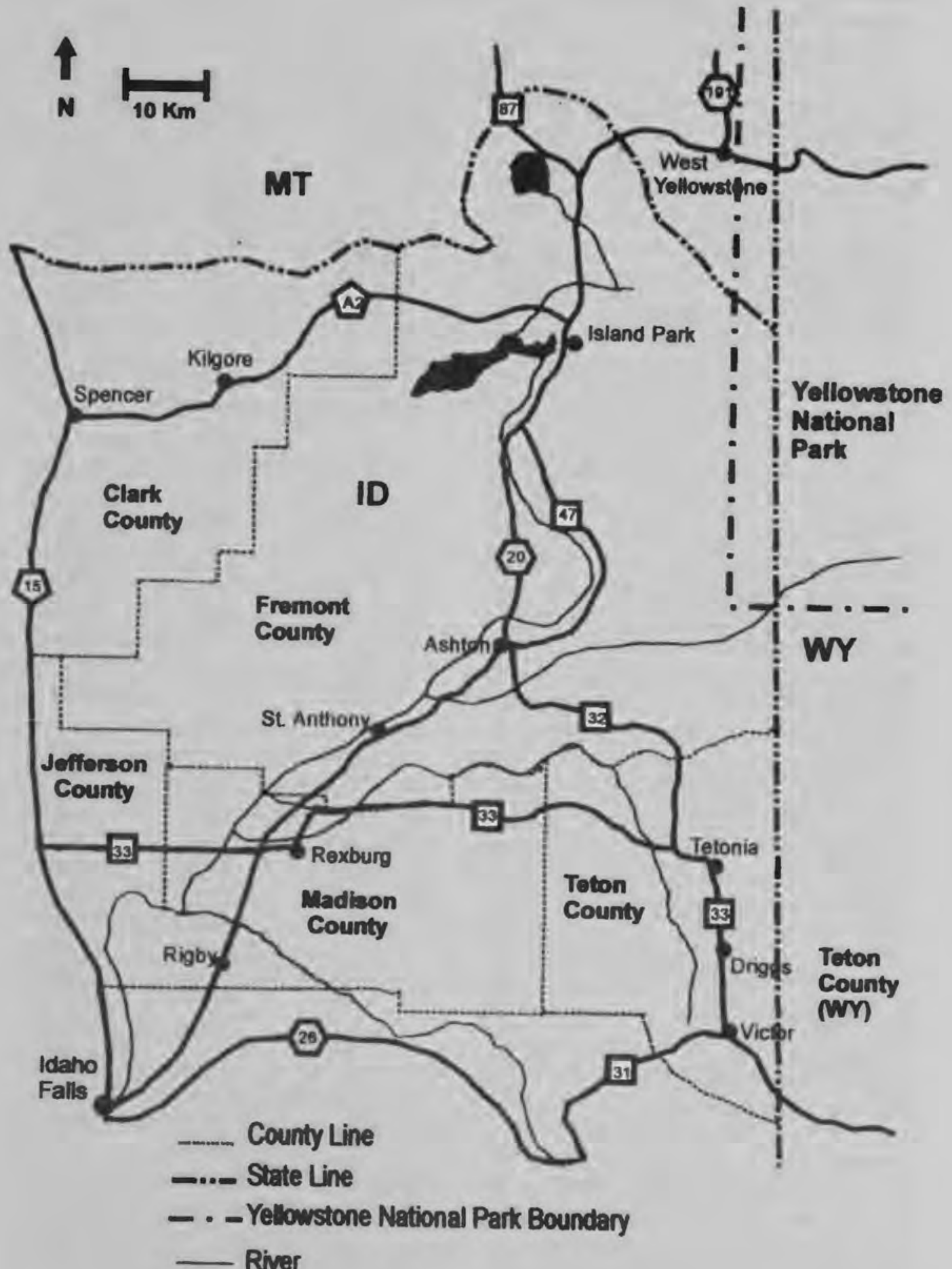

Figure 6. *Major towns, roads and jurisdictions in and around the Henry's Fork watershed.*

land area is federally owned; most of this is forest and range land lying in the Targhee-Caribou National Forest.

The economy and cultural landscape of the Henry's Fork watershed is changing, as in most other regions of the western U.S. An economy once dominated by farming, ranching, and logging is giving way to one with more diversity, as people are moving into the area for its recreational opportunities and quality of life. Tourist businesses based around fishing, skiing, and snowmobiling are thriving in Island Park and Teton Valley. Construction is a major occupation in Teton County, reflective of a large building boom there and in Jackson. Many Teton Valley residents commute to Jackson for work. Enrollment at Ricks College, a two-year Mormon school in Rexburg, has exceeded 8,000, and the Church of Jesus Christ of Latter Day Saints recently announced that the college will soon become a four-year branch of Brigham Young University. This change should bring further economic growth to Rexburg, which also is home to several manufacturing companies, including Artco Printing and Ultimate Direction outdoor products. Recently, scientists formerly employed at the National Engineering and Environmental Laboratory in Idaho Falls started a computer software company in St. Anthony. These changes in the socioeconomic makeup of the watershed will necessarily result in changes in natural resource management, particularly with respect to water, which has always been the limiting commodity in the arid west. The trend towards increasing levels of natural resource research, as exemplified by this issue, provide hope that the effects of changes in the economy and social composition of the Henry's Fork watershed will be less disruptive and destructive than they have been in many other parts of the west.

Table 5. *Land use and ownership in counties of the Henry's Fork watershed. Data from U.S. Geological Survey and Idaho Department of Commerce.*

	Fremont	Madison	Teton (ID)	Total
Land Area (km^2)	4835	1221	1167	7223
Land ownership				
Federal	59.5%	20.3%	33.0%	48.6%
State	9.6%	7.4%	0.6%	7.8%
City/county	0.0%	0.7%	0.1%	0.1%
Private	30.9%	71.7%	66.4%	43.5%
Land use				
Forest	44.9%	17.3%	32.4%	38.2%
Range	32.6%	8.6%	21.1%	26.7%
Agriculture	17.2%	67.4%	40.9%	29.5%
Other	5.3%	6.7%	5.6%	5.6%

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