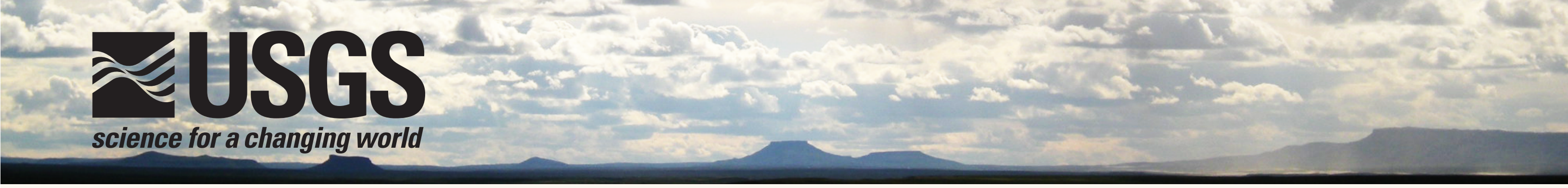

Monitoring the Southwestern Wyoming Landscape—
A Foundation for Management and Science

What is Monitoring?

Natural resource monitoring involves repeated collections of resource-condition data and analyses to detect possible changes and identify underlying causes of changes. For natural resource agencies, monitoring provides the foundation for management and science. Specifically, analyses of monitoring data allow managers to better understand effects of land-use and other changes on important natural resources and to achieve their conservation and management goals. Examples of natural resource monitoring on public lands include wildlife habitats, plant productivity, animal movements and population trends, soil chemistry, and water quality and quantity. Broader definitions of monitoring also recognize the need for scientifically valid data to help support planning efforts and informed decisions, to develop adaptive management strategies, and to provide the means for evaluating management outcomes.

Why is Monitoring Necessary?

Existing monitoring data can inform us about relations between past and present resource conditions. Ongoing monitoring is needed to assess future changes, including effects of management actions, wildfire, and shifting land uses. Moreover, existing or "baseline" data for many natural resources are lacking or inadequate for addressing the complex management needs of large-scale programs like the Wyoming Landscape Conservation Initiative (WLCI).

The WLCI is a science-based, long-term, landscape-level assessment of natural resource conditions across southwestern Wyoming. Major WLCI goals are to conserve the region's exceptional wildlife populations and its vital economies in agriculture and recreation while facilitating responsible development of the region's vast energy resources. Without long-term monitoring data to help guide land-use decisions, these goals would not be achievable.

Monitoring data representing past and current conditions provide a basis of comparison, or baseline, against which future conditions may be measured. That is, long-term monitoring data make it possible to detect trends in resource conditions. With trend information, managers can evaluate the effectiveness of management actions and inform adaptive management strategies. For example, the growth and cover of desired plant species on reclaimed gas well pads are monitored to determine whether reclamation goals are achieved. In turn, the data could provide the basis for refining revegetation methods and where to focus future reclamation efforts.

Herein, we highlight various monitoring approaches and applications used by the U.S. Geological Survey (USGS) and other WLCI partners to help address management needs and achieve conservation goals of the WLCI effort. Indeed, a relatively small investment in natural resource monitoring provides both immediate and long-term conservation benefits while facilitating responsible land-use practices.

U.S. Department of the Interior
U.S. Geological Survey

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Managing Multiple Resources and Land Uses through Coordinated Monitoring Efforts

Southwestern Wyoming is richly endowed with large areas of intact wildlife habitat, productive agricultural lands, nationally significant energy and mineral reserves, and world-class recreational opportunities. However, managing landscapes for such disparate resources and land uses presents major challenges further complicated by the region’s mosaic of Federal, State, and private lands. Implementing a well-coordinated, carefully designed resource monitoring program helps to ensure that rigorous standards will be applied to data collection and the data will be statistically powerful enough for early detection of small changes in resource conditions. Overall, a solid monitoring program makes it possible to closely track and distinguish different trends in resource conditions across complex landscapes, quantify cumulative effects of land-use changes, evaluate management-action effectiveness, and identify and fill data gaps. In turn, resource managers gain the information they need to address potential land-use conflicts and protect natural resource values.

Monitoring Wildlife and Habitat—Mule Deer Migration

Monitoring wildlife habitat use and movement patterns can provide information crucial for supporting conservation management decisions. For example, tracking mule deer fitted with global positioning system (GPS) collars has allowed USGS scientists to identify their migration routes and stopover sites, which is crucial for managers seeking to protect these habitats. It also reveals how deer use habitat and other resources along their routes, which is important for assessing the benefits of migration. One such benefit is prolonged access to high-quality forage.

When mule deer depart their winter ranges, typically they are in poor condition, and the females soon face the added physical demands of giving birth and caring for their young. Therefore, the quality of forage at migration stopovers can affect the reproductive success and survival of individual deer. The new plant growth that emerges during spring green-up is highly digestible and nutritious, thus deer actively seek this food resource. Nonmigratory deer have only brief access to the quality forage of spring green-up, whereas migratory deer greatly prolong their access by tracking the progression of green-up as they migrate from their low-elevation winter ranges to their higher-elevation summer ranges (fig. 1). This behavior is known as “surfing the green wave” (fig. 2).

A growing concern is the potential effect of changing weather patterns on the green wave. For example, USGS researchers found that spring green-up was more rapid than usual during a major drought in 2013, reducing the access deer had to high-quality forage. Drought could also disrupt the green wave, making the pattern of green-up more random and difficult for deer to track. Additional long-term monitoring and research are needed to better understand how drought may affect mule deer populations in the long run.

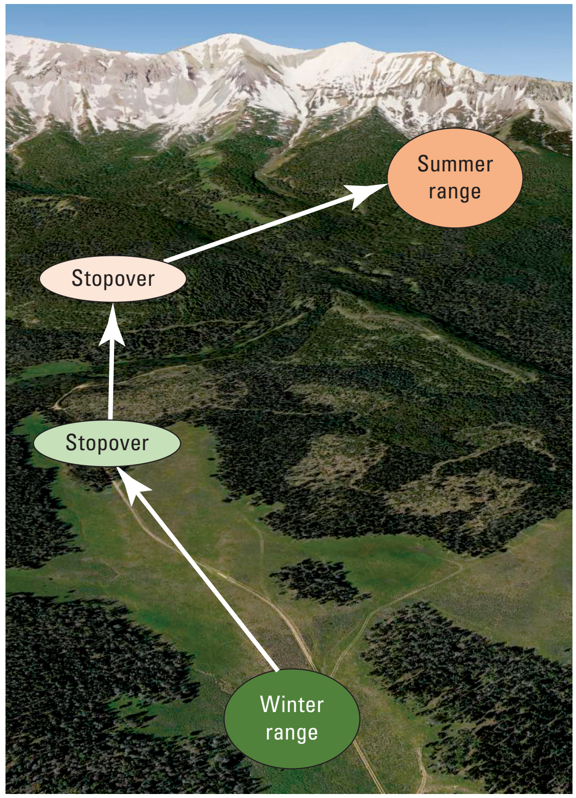

Figure 1. Migration routes can provide important feeding and resting habitat for a diversity of animals. In spring, as mule deer migrate from low-elevation winter ranges to high-elevation summer ranges, they move in sync with the emergence of new plant growth, which is highly nutritious.

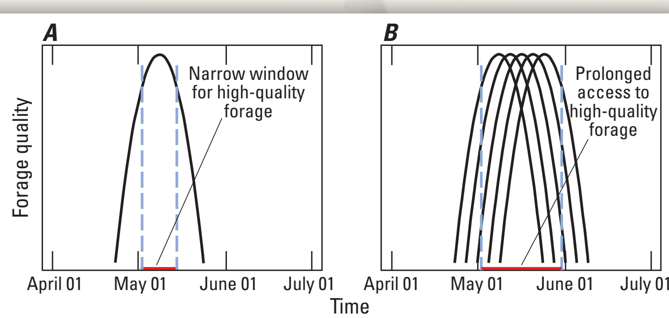

Figure 2. *A*, The period during which nonmigratory mule deer have access to new plant growth of spring green-up (bounded by the dashed blue vertical lines and red horizontal line) is short compared to that of *B*, migratory mule deer, whose movements from winter to summer ranges allow them to “surf the green wave” of spring green-up. By prolonging their access to the highly nutritious new plant growth, deer reap a major benefit from migration.

Effectiveness Monitoring and Adaptive Management

Natural resource managers in the WLCI region frequently implement management actions designed to enhance, restore, or protect priority wildlife habitats, such as sagebrush steppe, mountain shrublands, and aspen woodlands. To better understand how effectively these management actions achieve conservation goals, it is essential to monitor habitat and wildlife responses to them. Additionally, the information acquired through a well-designed effectiveness monitoring program is needed for developing adaptive-management strategies and modifying actions that do not achieve desired outcomes. Indeed, a major focus of the WLCI has been to evaluate effectiveness of habitat treatments, including differential effects of treatment type, timing, and location, to help guide future habitat-management actions.

To accurately interpret the results of individual habitat treatments, it is also crucial to consider the long-term, landscape-scale context, such as changing land uses or climate patterns, which could affect interpretations of local treatment outcomes. For example, management actions implemented by WLCI land managers to rejuvenate declining aspen woodlands resulted in a range of responses, from vigorous rejuvenation to accelerated decline. It was suspected that long-term drought and local factors that buffered some sites against drought were factors in these discrepancies. To address this hypothesis, USGS scientists are using retrospective analyses to provide the broader spatial and temporal perspective required for fully understanding local responses to management actions.

Retrospective analyses use existing long-term data obtained from the archives of Landsat satellite imagery, weather data, and other long-term databases. For assessing aspen woodland responses to habitat treatments, USGS scientists are using Landsat data that indicate moisture content of the vegetation canopy (foliage). From the moisture data, a series of canopy condition indices are developed and analyzed to reveal long-term trends in canopy condition (fig. 3). Incorporating a series of drought indices for the same time period can provide insights about potential relations between canopy condition and long-term drought.

A large-scale, long-term perspective in canopy condition also provides a basis for comparing post-treatment habitat responses with pretreatment conditions to help account for nontreatment effects on habitat responses or differences among untreated (control) sites. It is crucial, however, to incorporate field data in the analyses to ensure correct interpretations of the satellite data. For example, even if the canopy condition index for an aspen woodland was stable over time, vegetation data collected from those sites could reveal that the aspen had died out and been replaced by serviceberry shrubs.

Retrospective analyses are also used to assess how resistant and resilient treated habitats are to long-term, regional disturbances, such as drought, invasive species, or land-use changes. Finally, retrospective monitoring can be used to lengthen a period of long-term natural resource monitoring, which would help to conserve funds and personnel time. Overall, information acquired from effectiveness monitoring and retrospective analyses provides resource managers with information that makes it possible to thoroughly assess the efficacy of management actions and broad-scale influences that affect the potential for achieving conservation goals.

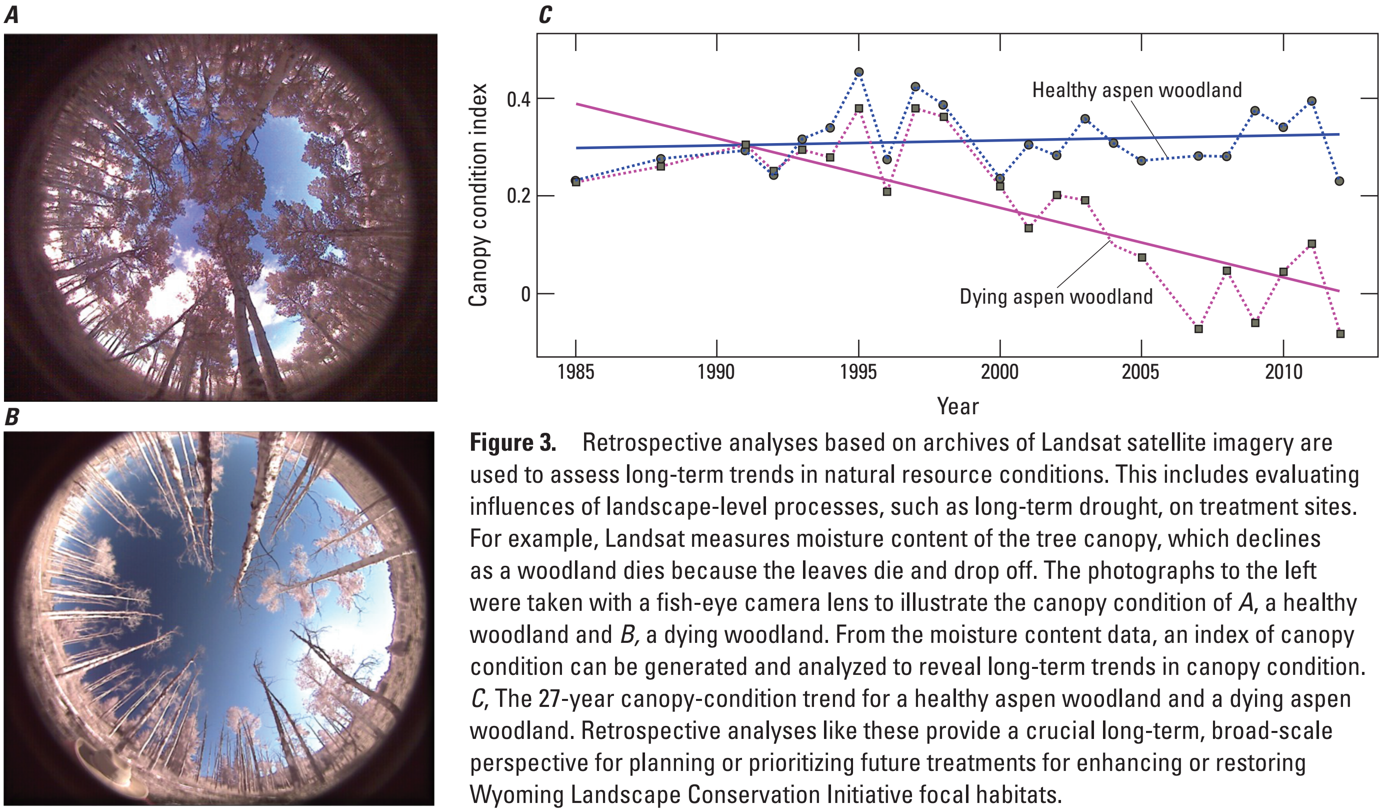

Figure 3. Retrospective analyses based on archives of Landsat satellite imagery are used to assess long-term trends in natural resource conditions. This includes evaluating influences of landscape-level processes, such as long-term drought, on treatment sites. For example, Landsat measures moisture content of the tree canopy, which declines as a woodland dies because the leaves die and drop off. The photographs to the left were taken with a fish-eye camera lens to illustrate the canopy condition of *A*, a healthy woodland and *B*, a dying woodland. From the moisture content data, an index of canopy condition can be generated and analyzed to reveal long-term trends in canopy condition. *C*, The 27-year canopy-condition trend for a healthy aspen woodland and a dying aspen woodland. Retrospective analyses like these provide a crucial long-term, broad-scale perspective for planning or prioritizing future treatments for enhancing or restoring Wyoming Landscape Conservation Initiative focal habitats.

Monitoring, Detecting, and Mapping Changes in Sagebrush Habitat

The cornerstone of habitat monitoring in the WLCI region is an affordable, repeatable set of protocols developed by USGS scientists. The approach entails combining field sampling data and remote sensing for estimating the percent cover of sagebrush, plant litter, and bare ground across the entire WLCI landscape (fig. 4). The resulting data describe the distribution of and variability in sagebrush habitat, and they provide a baseline for monitoring long-term changes in habitat conditions. This type of information is crucial for understanding current and future conditions in sagebrush systems. The data also will help scientists understand the relations between habitat conditions and drivers of change, such as development and climate.

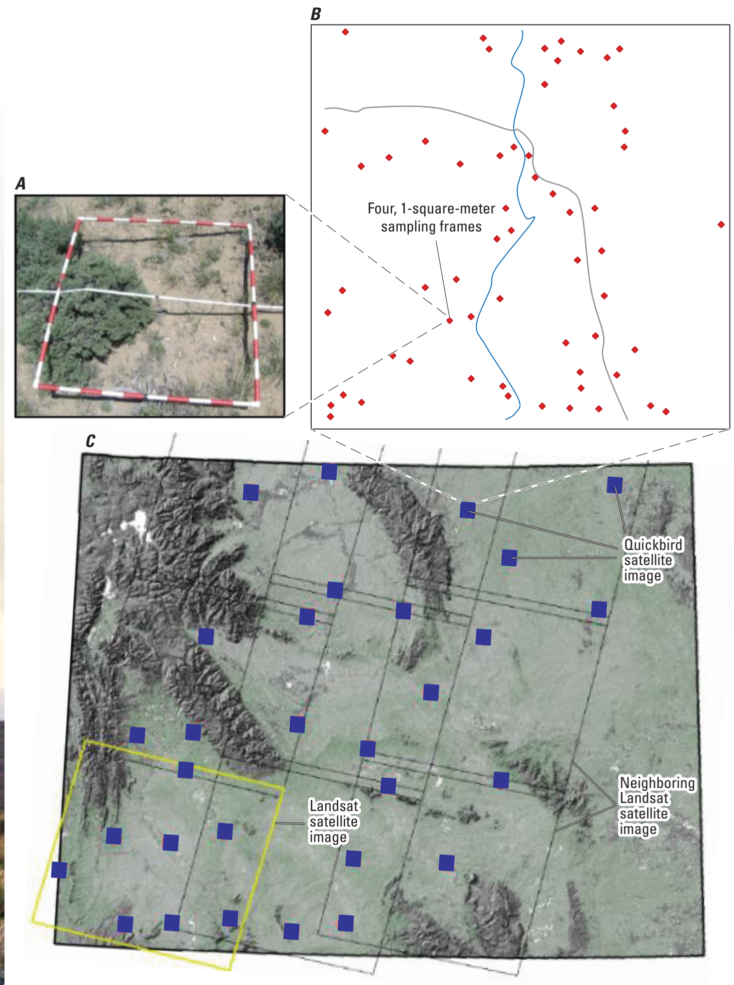

Figure 4. Multiscale mapping is an approach taken by U.S. Geological Survey scientists to monitor sagebrush landscapes. This process involves *A*, field sampling vegetation cover in hundreds of 1-square-meter frames distributed across *B*, the area depicted by a high-resolution (much detail, small area) image captured by the Quickbird satellite. In turn, many Quickbird images are distributed across *C*, a medium-resolution (less detail, larger area) image captured by a Landsat satellite. By sampling vegetation on the ground, small but important distinctions can be made for correctly classifying vegetation characteristics that could be misinterpreted from satellite images alone. The field data then are used to "train" the Quickbird images to enhance their "interpretations" of vegetation cover on the ground. Finally, the enhanced Quickbird imagery is used to "train" the Landsat imagery. The outcome of this multiscaling approach to mapping vegetation cover is a reasonably accurate picture of vegetation cover at any one time across a large area. By repeating this process over time and comparing results, it becomes feasible to monitor changes across entire landscapes with minimal effort and expense.

Integrating Habitat and Population Monitoring

Successful, long-term wildlife conservation depends on understanding the relations between habitat conditions and animal behaviors, distributions, and demographics. Because wild animals respond to both local habitat conditions and the distribution of habitat across large areas, it is also important to consider patterns in and conditions of habitats from local to regional scales. This is particularly true when designing monitoring programs for species with broad distributions.

Building on years of wildlife habitat and population research conducted by many agencies and universities, USGS and Colorado State University scientists are modeling and monitoring the relations between habitat conditions and wildlife responses to changing conditions, for greater sage-grouse in particular. Understanding the habitat needs of a broadly distributed species like the sage-grouse requires knowledge of seasonal movement patterns, juvenile dispersal, habitat preferences, habitat fidelity, and habitat conditions. Assessing the links between wildlife populations, habitat conditions, and disturbances associated with human activities are important because the resulting information can help to inform management decisions.

Extensive research has already been conducted to document rangeland conditions, range-wide distribution of sagebrush and other aspects of sagebrush habitats, ecosystem resistance to change and resilience after disturbance, and responses of habitats and species to surface disturbance, habitat treatments, and other human activities. Researchers are also assessing the spatial distribution and demographics of sage-grouse populations. This includes evaluating population genetics, which can provide crucial information about animal movements and population mixing. Understanding and monitoring ecosystem conditions and the responses of habitats and wildlife to natural and human-generated changes will provide the information needed to help balance land uses with wildlife and habitat conservation.

Monitoring Energy Development

There are potentially extensive, recoverable (undiscovered) energy resources that underlie the WLCI region, including, natural gas, coal, coal-shale and oil. As these reserves are developed, long-term monitoring is needed to assess wildlife and habitat responses to development and to mitigate potential negative effects. Models that simulate potential future conditions can be powerful aids for long-term monitoring programs. For example, modelers can incorporate conventions and procedures for developing oil and gas wells and access roads to map realistic scenarios of future energy development (fig. 5). Simulation results then can be used to determine where long-term monitoring efforts could be established to better understand the long-term effects of development on wildlife species habitat and populations. By the same token, planning and management teams can use these scenarios to anticipate effects of development and develop mitigation options in advance of development.

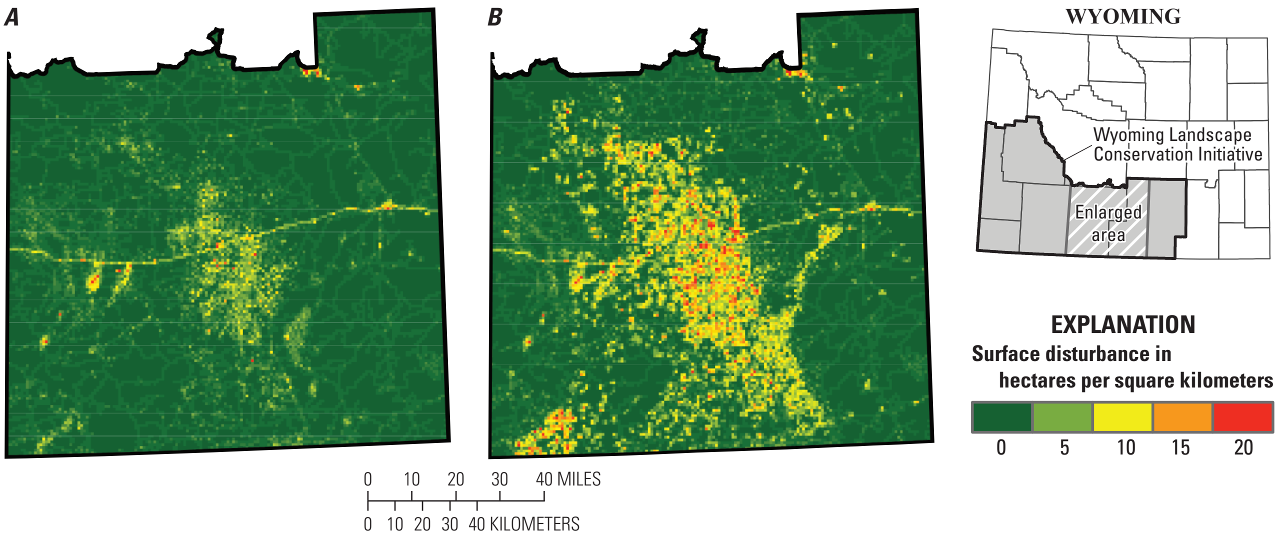

Figure 5. Surface disturbance from oil and gas drilling *A*, up through 2012 and *B*, simulated up to 2042 in the south-central portion of the Wyoming Landscape Conservation Initiative study area, where intense development is projected to occur in the future. Areas where surface disturbance changes substantially from 2012 and 2042 may be candidates for focused monitoring efforts to understand how trends in development could influence wildlife habitat quality and population numbers.

Monitoring Water Quantity and Quality

In the semiarid WLCI region, rivers and groundwater are tapped for irrigation, municipal and domestic water supplies, and energy development. They also provide crucial habitat for aquatic life and drinking water for livestock and wildlife. Changing land uses throughout the region, however, have the potential to affect these vital, but limited, water resources. For example, surface disturbances associated with building roads and oil and gas well pads could lead to increased soil erosion; in turn, larger amounts of sediments and dissolved minerals could flow into nearby rivers, thereby diminishing their quality and habitat value. To monitor streamflow and water quality in areas of current and potential future energy development, USGS scientists expanded an existing network of streamgages. By monitoring water resources in landscapes affected by land-use changes, scientists can detect changes in water resources and gain insights about how natural and human-induced changes to the landscape affect water quantity and quality.

To increase the understanding of groundwater and stream interactions, USGS drilled shallow wells near the New Fork and Green Rivers of southwestern Wyoming to pair them with existing streamgages. Comparisons of the temperatures and water elevations in the wells and rivers provide insights about how the groundwater interacts with the rivers. For example, data from the well in figure 6 indicate when water is flowing from the river into the groundwater or from the groundwater into the river. Additional calculations can determine the volume of water exchanged along a section (reach) of river. Where groundwater flows into a given reach, the water remains cooler in summer and warmer in winter than it would without this influence. In turn, groundwater inflows enhance riverine habitats for fish and other aquatic animals. Ultimately, monitoring data collected at these paired sites will help USGS scientists determine whether and how changes in land and water use, including withdrawals from local wells, affect the condition of rivers in the WLCI region.

Figure 6. U.S. Geological Survey scientist accesses a well on the west side of the New Fork River near Big Piney, Wyoming. Instrumentation in the well and in the river continuously measure water levels and temperature and transmit the data to the nearby streamgage (green structure in the background). By comparing well and streamgage data, scientists determined that some water flows from the river into the groundwater in summer months, whereas in the winter months water flows from groundwater into the river.

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Please contact us for more information or to share your ideas and monitoring needs. Also check out the WLCI Monitoring website at https://www.wlci.gov/monitoring.

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