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**The Technical Newsletter of the National Stream and Aquatic Ecology Center**  
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### **Case Study: Jackknife Creek Watershed Restoration**

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The Jackknife Creek Watershed near the Idaho-Wyoming border on the Caribou-Targhee National Forest began its *Restoring Hope* journey with restoration efforts

initiated in 2006 to improve watershed health and conditions. The Jackknife Creek subwatershed (30,425 acres, -95% on National Forest) was selected as a priority watershed in 2011 following the implementation of the [Watershed Condition Framework](#), with the watershed rated in fair condition and considered on the verge of change. By 2014 it was one of 10 watersheds out of more than 15,000 on Forest Service-managed public lands where efforts (Figure 1) culminated in a changed condition class. “No one agency, no one

StreamNotes is an aquatic and riparian systems publication with the objective of facilitating knowledge transfer from research & development and field-based success stories to on-the-ground application, through technical articles, case studies, and news articles. Stream related topics include hydrology, fluvial geomorphology, aquatic biology, riparian plant ecology, and climate change.

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**Figure 1:** Pre- and post-restoration condition at a crossing of Squaw Creek, a tributary of Jackknife Creek.

individual, can accomplish this kind of work. It's an effort of many" stated Brent Larson, Forest Supervisor (now retired). In recognition of these restoration efforts, in 2016 the Caribou-Targhee National Forest, Trout Unlimited, and partners were awarded the first annual Aquatic Habitat Award by the Idaho Chapter American Fisheries Society.

With 86 miles of perennial streams and 26 miles of fish-bearing reaches, the Jackknife Creek watershed is a stronghold for two sensitive species including Yellowstone cutthroat trout and northern leathersides chub, and is an important spawning tributary of the Salt River (in the Snake River basin). The Jackknife Creek Watershed contains relatively few roads (12 miles on National Forest and 3 miles on private lands), though they are located primarily within sensitive riparian corridors. The roads provide access to trailheads with 43 miles of trails. The private lands are dominated by agricultural practices, with pre-restoration impairments including unscreened and dilapidated diversion structures, unstable road stream crossings, active bank erosion, minimal riparian buffers, and straightened stream channels.

Three Forest Service roads split off at the lower end of the watershed and parallel Jackknife, Squaw, and Deep Creeks, the primary streams within the watershed. These roads and adjacent streams have had a number of management problems. Several road crossings exist, with some identified as being undersized with different degrees of barriers to aquatic organism passage. A 2011 high flow event on Squaw Creek washed out ford stream vehicle crossing, forcing an administrative closure of about 1 mile of road to avoid unsafe travel conditions. The last 1.6 miles of the Jackknife road, which provided trailhead access,

was administratively closed in 2006 due to hillslope slump failure. In addition, the last roadway bridge crossing of Jackknife Creek had a 24 foot bridge span that significantly restricted the 35 foot bankfull channel, with road approaches elevated 3 to 5 feet to supposedly improve road conditions. These elevated road approaches restricted flood flows from accessing 270 feet of floodplain width. Additionally, channel straightening substantially reduced the channel length, with resulting loss of associated aquatic and riparian habitat length and complexity. The changes in channel hydraulics coupled with other management activities (grazing, beaver removal, etc.) caused Jackknife to downcut as much as 3 to 4 feet.

The Watershed Condition Framework classification utilized the 24 attributes and 12 indicators to represent these pre-restoration conditions that were resulting in sedimentation, poor drainage, reduced water quality, reduced aquatic habitat and passage, channel downcutting, loss of habitat, and excessive bank erosion rates. The Jackknife Creek Watershed was scored at 1.7, which is on the low end of the *Fair* condition class and on the verge of transitioning to a *Good* condition class (Table 1).

## Development of Restoration Projects

The [Jackknife Creek Watershed Restoration Action Plan](#) (WRAP) was developed in 2011 to identify essential projects to address and build upon the ongoing projects to improve condition within the watershed. Two Environmental Assessments (EAs) were completed to formulate solutions to the resource concerns. The mitigation measures consisted of relocating or decommissioning roads and trails within the riparian zone, road and

trail stream crossing improvements, and stream restoration. The stream restoration components consisted of 3.9 miles of channel work, to restore lost function and improve the quantity and quality of aquatic habitat, boost water quality, and enhance riparian health and function. In addition, restoration projects on private lands and county roads addressed deficient water diversions, undersized stream crossing, and unstable channel conditions. Overall, the restoration work cost \$849,000, with 79% and 21% of the cost paid by the Forest Service and partners, respectively. Of the Forest Service funding, about 95% was internal funding specifically directed toward this effort.

**Table 1:** Jackknife Creek Watershed Indicators and Ratings. Classification and scoring: Class 1 (Good) = scores of 1.0 to 1.6; Class 2 (Fair) = scores 1.7 and 2.2, and Class 3 (Poor) = scores from 2.3 to 3.0.

Watershed Condition Indicator	Score and Rating
Water Quality	2.0 - Fair
Water Quantity	1.0 - Good
Aquatic Habitat	2.0 - Fair
Aquatic Biota	2.0 - Fair
Riparian & Wetland	
Vegetation	2.0 - Fair
Roads and Trails	1.75 - Fair
Soils	1.3 - Good
Fire Effects / Fire Regime	1.0 - Good
Forest Cover	2.0 - Fair
Rangeland	
Vegetation	1.0 - Good
Terrestrial Invasive Species	1.0 - Good
Forest Health	1.5 - Good

Accomplishments of the watershed restoration include:

- 20,780 feet of active restoration and fisheries enhancement on Jackknife, Squaw, and Deep Creeks, including 2,400 feet of improved critical stream reaches on private lands



- 1.3 miles of decommissioned roads
- 2.5 miles of roads converted to trails, to reduce riparian disturbance
- 6 miles of trail relocated and improved to standard and 20 miles of trail maintained to standard
- 7 trail stream crossing upgraded to bridges and 1 trail stream crossing eliminated
- 9 undersized road stream crossing upgraded to open bottom structures to improve stream function, restore aquatic passage, and improve water quality
- 6.3 miles of road improved via heavy reconstruction, drainage improvements and re-surfacing
- 166 acres of watershed improvements
- 1,131 acres of wildlife habitat improvement
- 23 miles of stream habitat improved or made available for aquatic organisms through barrier removals that directly benefited the Yellowstone cutthroat trout and northern leathersides chub

- Professional Video Production in partnership with Trout Unlimited: [Restoring Hope](#)
- Maintained jobs in SE Idaho through local contracts and agency involvement

## Sample Details of Restoration Projects

The implemented projects occurred throughout the watershed and are grouped in three main catchments: Deep Creek, Jackknife Creek, and Squaw Creek.

### Deep Creek

Deep Creek is the lowest tributary drainage in the watershed, with the headwaters on National Forest. Improved road-stream crossings and a stream restoration (on private land) were the primary restoration components. The Caribou-Targhee National Forest cooperatively worked with Rec Spackman (the private landowner), Bonneville County, Trout Unlimited, and other partners to replace a fish barrier culvert on Deep Creek and restore over 1,100 feet of straightened and incised stream channels (Figure 2).

The replacement of the 4 foot diameter culvert with an 8 foot wide natural bottom arched pipe by Bonneville County on Jackknife Road (FS 136) restored passage for Yellowstone Cutthroat trout onto the National Forest. The channel was restored using stable reference conditions. The nearly 8 foot deep incised channel was elevated up to 5 feet to reconnect the channel to a newly constructed floodplain. The flood-prone width was increased from approximately 15 foot to nearly 80 foot, reducing unit stream power and increasing stability during flood events. Meandering was reintroduced, matching reference conditions (sinuosity increased from 1.1 to 1.5). Gravel and cobble stream bed materials were imported to mimic the natural channel riffles and provide grade control. Channel bank reconstruction, for lateral stream stability and increase aquatic habitat complexity, consisted of meander log complexes, whole willow clump transplants; transplanted sedge clumps, sod matting, and application of native seed mixes.

The Forest Service collaborated with Bonneville County and utilized Forest Service Force Account Road Crew and the Bonneville County Road and Bridge Crew to replace 8 undersized stream crossings that had caused channel instability and erosion, and were fish barriers to the Yellowstone cutthroat trout. The road/stream crossing upgrades eliminated fish barriers, opening up more than 6 miles of stream for migration. In association with the culvert upgrades, 2 miles of road were reshaped and spot graveled to improve drainage and reduce erosion.



**Figure 2:** Deep Creek, before and 4 years after restoration.



## Jackknife Creek

Restoration on Jackknife Creek consisted of road decommissioning, road to trail conversion, road and trail stream crossing improvements, stream restoration, and diversion improvements. This work was performed both within and adjacent to the National Forest using partnership collaborations.

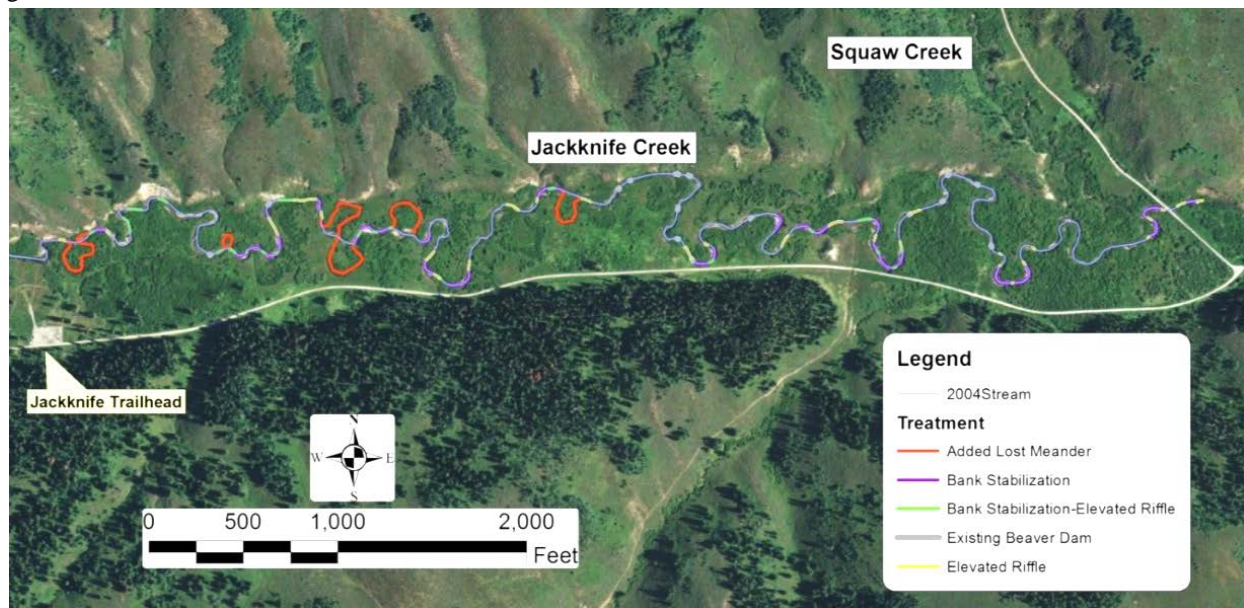
Upstream, within the National Forest, the Forest Service worked with the Northwest Youth Corps (NYC) and Trout Unlimited to accomplish a number of projects, including recreational access improvements (new parking lot and trailhead 1.9 miles lower in the drainage, with road decommissioning to avoid the slumped road failure), and upgrading 4 undersized stream crossings. This included the replacement of 24 foot Jackknife Road Bridge with a 55 foot non-motorized trail bridge (Figure 3) and removal of 3 to 5 feet of elevated approach embankment to allow future flood events to access the 270 feet floodplain width. Additionally, the partnership performed 3.9 miles of stream restoration on Jackknife Creek. The goal of this restoration was to



**Figure 3:** Jackknife Creek road bridge replacement and conversion to a wider-span, non-motorized trail crossing. Before and after restoration photos are provided.

increase channel function and stream stability, improve fish habitat, restore riparian function, and improve water quality. Restoration (Figure 4) consisted of restoring channel stability via elevating the stream channel to historic levels, re-activating a lost meander cutoff, and stabilizing

eroding stream banks. This work included the re-activation of abandoned meanders. The bank stability treatments used whole tree revetment intermixed with transplanted willow clumps, and onsite cobble-sized toe rock, or trenched whole willow clumps and cobble-sized toe rock to re-build



**Figure 4:** 2012 and 2014 Jackknife Creek stream restoration of 3.9 miles of stream.

eroding banks to promote long-term stability.

Downstream of the National Forest boundary, a total of 1,300 feet of stream channel was rehabilitated and stabilized. The incised channel was elevated 1.5 to 3.0 feet in the vicinity of the diversion, using boulder grade control and hardened riffle structures. Accelerated bank erosion was treated with whole tree revetment and relocated whole willow clumps to mimic log jam complexes and create stream stability. A potential meander cutoff was retained as a flood flow channel with the use of log jam complexes type structures, to increase stream stability and created aquatic habitat complexity. The diversion upgrade project consisted of the installation of a fish screen and diversion structure along with 2,000 feet of piped ditch, to provide private land owners with their decreed water right. Idaho Fish and Game designed, fabricated and oversaw the installation of a solar-powered single-drum modular unit that met NOAA criteria (Figure 5).



**Figure 5:** Solar-driven drum screen installed on the Jackknife Creek diversion. Viewed up ditch line, with a fish bypass pipe on the lower left and the ditch pipeline entrance on the lower right.

### Squaw Creek

Squaw Creek is a tributary to Jackknife Creek, with restoration components consisting of road to trail conversions, road improvements, and a trail bridge replacement. The upper portion of Squaw Creek road (1.8 miles) was converted to an ATV trail to narrow the disturbance width

within the riparian corridor. Two upgraded stream crossings were constructed. The washed-out full size vehicle ford was converted to a new 30 foot span timbered ATV trail bridge and the undersized 5 foot culvert was replaced with a 30 foot timbered trail bridge. The lower portion of the road (1.6 miles) leading to a trailhead and sheep corral was also improved, including elevating 0.3 miles of road in multiple locations (to prevent beaver dam inundation), installing cross drain culverts, and reshaping and graveling 1.6 miles of road (including the parking area at the Squaw Creek trailhead). Additionally, 600 feet of streambanks that were eroding into the road edge were stabilized.

A washed out trail timbered bridge was replaced with a 35 foot bridge to more effectively span the active channel and a portion of the floodplain. A degraded reach of Squaw Creek and a tributary confluence was also restored (Figure 1).

### Additional Information

In cooperation with Trout Unlimited, a video (*Restoring Hope*) was produced to highlight the phase 1 restoration efforts. It is [available on YouTube](#).

### Management Implications

- Upon completing the last essential project on National Forest in 2014, the Jackknife Creek Watershed has been improved and meets the criteria to shift it from a *Fair* to *Good* watershed condition class rating.
- Restoration performed within the Watershed Condition Framework attracts external partners and funding that is critical for tackling expensive and complex restoration project. These restoration efforts need to be supported by Forest

leadership teams to allow specialists the necessary time to collaborate with partners, develop projects, and oversee implementation.

- The implementation of the Watershed Condition Framework on the Caribou-Targhee National Forest focused efforts in one watershed on one of seven districts. It is important to note watershed restoration efforts continue on the other districts to accomplish important needs, engage interested partners, and utilize available external funding to improve resource conditions across the forest.
- Many of these project are multi-year efforts. It is critical that agreements be structured to secure or obligate funding for multiple years.

### Acknowledgements

Significant partnerships and funding contribution made this Jackknife Watershed Restoration effort possible. Without the efforts by each and every one of these partners, none of the Jackknife Creek watershed improvements would have been possible. Special thanks goes to Trout Unlimited, USFWS, Bonneville County, NRCS, Eastern Idaho RAC, Private landowners, Idaho Fish and Game, Idaho Parks and Recreation, Eagle Rock Backcountry Horsemen, and NW Youth Corp.

In addition to external partners, the strong internal integration with district rangers, staff officers, the forest supervisor, engineers, recreation specialist, fisheries biologists, hydrologists, soil scientists, botanists, range specialists, force account road crew, and equipment also contributed to a highly successful effort at making a difference for the public and resources benefit.



## Notices and Technical Tips

- **Direct technical assistance from applied scientists at the National Stream and Aquatic Ecology Center** is available to help Forest Service field practitioners with managing and restoring streams and riparian corridors. The technical expertise of the Center includes hydrology, fluvial geomorphology, riparian plant ecology, aquatic ecology, climatology, and engineering. If you would like to discuss a specific stream-related resource problem and arrange a field visit, please [contact a scientist](#) at the Center or [David Levinson](#), the NSAEC program manager.
- The Environmental Protection Agency has a new online training module [Understanding Climate Change Impacts on Water Resources](#). This training is intended to increase water resource professionals' understanding of the causes of climate change, its potential impacts on water resources, and the challenges that water resource professionals face. The module describes how federal, state, tribal, and local governments and communities are working to make the United States more resilient to the impacts of climate. The 45-minute training is part of the EPA [Watershed Academy](#) certificate program.



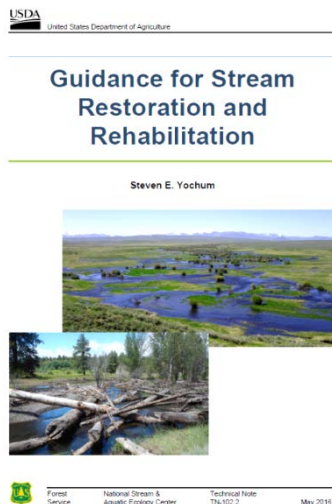
- A partnership between Freshwaters Illustrated and the U.S. Fish and Wildlife Service produced a video on the **reintroduction of endangered bull trout on the Clackamas River**, in Oregon (Mount Hood National Forest). Bull Trout were extirpated from this watershed during the 20<sup>th</sup> century due to logging practices, excessive sediment, fish passage blockage, and intentional overfishing (due to concerns of predation by bull trout on salmon and steelhead). The video is available [here](#). Additional information is available [at this website](#).

- **The Forest Service Pacific Northwest Research Station has hired J. Ryan Bellmore, PhD**, as a new research fish biologist based in Juneau, Alaska. “My research focuses on the ecology of streams, rivers and lakes. These freshwater ecosystems are some of the most imperiled environments on Earth, and as a result, are frequent targets for restoration. Much of my research is aimed at evaluating: (1) the impacts of human degradation and environmental change on freshwater ecosystems, and (2) the potential consequences of different management strategies designed to mitigate or reverse the undesirable impacts associated with system change. The overall objective of my research is to gain a better understanding of complex mechanisms that support the resilience and productivity of these important ecosystems, and in so doing, contributing to better-informed restoration, conservation and stewardship of freshwater resources. I am particularly interested in food webs, which describe the flows of energy and material that support organisms, populations, communities, and ultimately, the natural resources and ecosystem services that freshwaters provide. My current research involves combining tools and theory from food web ecology, ecosystem ecology and system dynamics modeling to understand the flows of energy that support populations of Pacific Northwest salmon and steelhead during their freshwater residence.”
- The Seattle Times featured an extensive article on the **dam removals and watershed restoration on the Elwha River**. “The first concrete went flying in September 2011, and Elwha Dam was out the following March. Glines Canyon Dam upriver tumbled for good in September 2014. Today the river roars through the tight rock canyon once plugged by Elwha Dam, and surges past the bald, rocky hill where the powerhouse stood. The hum of the generators is replaced by the river singing in full voice, shrugging off a century of confinement like it never happened. Nature’s resurgence is visible everywhere.” The article [is available here](#).



## Notices and Technical Tips

- The National Stream and Aquatic Ecology Center has released an **update to the technical note *Guidance for Stream Restoration and Rehabilitation*** (TN-102.2). It is [available here](#). The abstract follows:



*A great deal of effort has been devoted to developing guidance for stream restoration and rehabilitation. The available resources are diverse, reflecting the wide ranging approaches used and expertise required to develop stream restoration projects. To help practitioners sort through all of this information, a technical note has been developed to provide a guide to the wealth of information available. The document structure is primarily a series of short literature reviews followed by a hyperlinked reference list for the reader to find more information on each topic. The primary topics incorporated into this guidance include general methods, an overview of stream processes and restoration, case studies, and methods for data compilation, preliminary assessments, and field data collection. Analysis methods and tools, and planning and design guidance for specific restoration features, are also provided. This technical note is a bibliographic repository of information available to assist professionals with the process of planning, analyzing, and designing stream restoration and rehabilitation projects.*

## Environmental DNA (eDNA) Sampling: Revolutionizing the Assessment and Monitoring of Aquatic Species

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Environmental DNA (eDNA) is DNA that has been released by an organism into the environment, such as air, water, or soil. Because DNA sequences can be used to identify species, it is possible to examine DNA from environmental samples e.g., a water sample (Figure 6), to determine species presence without having to observe an organism. There has been an

explosion of research on using eDNA sampling to detect aquatic species – fishes, amphibians, mollusks, crustaceans, and insects – over the last decade (Thomsen and Willerslev 2015).

Research on the use of eDNA has been a focus of the National Genomics Center for Wildlife and Fish Conservation (NGC) at the Rocky Mountain Research Station in Missoula, Montana. Work there and elsewhere has demonstrated that eDNA sampling can be as or more effective than conventional sampling for determining species presence. For example, following the [protocol](#) developed by the NGC (Figure 7), it typically takes less than 15 minutes (from arrival to departure) to collect and catalog an

eDNA sample (Figure 8). Moreover, the equipment needed to collect a sample can be carried by a single person in a daypack. By adopting this protocol, we used eDNA sampling to describe the distribution of federally listed bull trout across 98 km of 1st- to 3rd-order streams in 8 days (McKelvey et al. 2016). Furthermore, eDNA-based methods have detected species at very low densities in streams. We achieved 100%



**Figure 6:** An eDNA sample being collected. It generally requires 8–9 minutes to filter 5 L of clean stream water.





**Figure 7:** eDNA sampling field training. The technique can be learned in about 30 minutes.

detection of caged brook trout across 162 samples at distances of up to 240 m downstream despite order-of-magnitude changes in stream discharge (Jane et al. 2015). We also estimated that the detection probability of a single sub-adult trout in 100 m of stream was 84%, double or triple the capture probabilities associated with electrofishing for many stream fishes (Wilcox et al. 2016). This combination of sensitivity, reliability, and efficiency suggests that eDNA sampling has the potential to transform species assessment and monitoring in streams.

Sampling of eDNA has many applications. For example, biologists have often used it for detecting the presence or distribution of invasive nonnative species, including New Zealand mudsnails or bullfrogs. A focus of many eDNA projects at the NGC has been whether attempts to remove nonnative species, such as brook trout or brown trout in mountain streams in the West, were successful or whether migration barriers to nonnative fish were

effective. The bulk of research at the NGC and elsewhere, however, has been directed at native species of conservation concern. For these species, eDNA sampling is particularly helpful because conventional sampling is sometimes difficult or even harmful. Because eDNA sampling is noninvasive and rapid, it has no effect on the target species and can generally be done without the permitting required by methods relying on direct detection. Perhaps the greatest advantage of eDNA sampling, however, is that it enables the rapid inventory of species presence at broad scales. An example of this is the [assessment of habitat occupancy by bull trout across its entire U.S. range](#). The eDNA surveys are directed at cold-water habitats that are predicted to be suitable for juvenile bull trout

by the [Climate Shield](#) model (Isaak et al. 2015), and performed at 1-km intervals to provide precise and reliable assessments of bull trout presence. The survey has been completed in two, 8-digit HUs and started in 10 others, and has already detected bull trout in locations where they had not been observed in decades and confirmed their absence from other streams. Both sets of observations are helpful to managers confronted with setting conservation priorities.

Finally, each eDNA sample represents a snapshot of aquatic biodiversity and can be tested for the presence of many species if eDNA assays are available. In that regard, the NGC has developed taxon-specific eDNA assays for a number of salmonid fishes including brook trout and bull trout (Wilcox et al. 2013), westslope cutthroat trout, Yellowstone cutthroat trout, and rainbow trout (Wilcox et al. 2015), brown trout, and Arctic grayling, as well as species such as North American river otters (Padgett-Stewart et al. 2015) and nonnative opossum shrimp. Developing eDNA assays for additional species is relatively straightforward, as long as care is taken in their design and testing and the results are shared in the peer-reviewed literature. Eventually, there will be genomic-based tools permitting the



**Figure 8:** The collected sample is stored in desiccant, with associated data recorded on the storage bag.



simultaneous assessment of many species. There are many challenges to their implementation and they may fail to attain levels of sensitivity comparable to the single-species method. Regardless of the approach, the eDNA samples being collected now constitute a biodiversity archive that can be stored indefinitely and will be suitable for later analyses involving single-species or whole-community techniques.

Although we have extolled the advantages of eDNA sampling for species detection, it is vulnerable to two problems: concluding that a species is absent when it is there (false negative), and concluding a species is present when it is not (false positive or false detection). Most research has focused on reducing the frequency of false negatives by improving laboratory techniques or sampling methods to increase sensitivity. Likewise, avoiding false positives involves strict adherence to laboratory standards and avoiding contamination of the sample in the field. Also, eDNA sampling is at its strongest when used for species detection; when direct observation or tissue sampling is necessary e.g., for determining age structure or for genetic analysis, other methods must be used. Nevertheless, the field of eDNA sampling has matured sufficiently that scientists at the NGC have partnered with state, tribal, NGO, and federal biologists from every state in the West to conduct eDNA sampling for species of local or national concern. We invite you to do the same. Please contact us or [visit our website](#) for more information.

## Management Implications

- Determination of species presence with eDNA sampling is faster, cheaper, and more reliable than traditional methods.
- Sampling with eDNA makes range-wide or whole-basin surveys feasible.
- A single eDNA sample can be used to assess presence of many species.

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## Wildcat5 for Windows, A Rainfall-Runoff Hydrograph Model

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The National Stream and Aquatic Ecology Center is pleased to announce the release of Rocky Mountain Research Station General Technical Report (RMRS-GTR-334), *Wildcat5 for Windows, A Rainfall-Runoff Hydrograph Model: User Manual and Documentation*. Wildcat5 is an interactive Windows Excel®-based software package designed to assist watershed specialists in analyzing rainfall-runoff events to predict peak flow and runoff volumes generated by single-event rainstorms for a variety of watershed soil and vegetation conditions. The model is intended for small catchments responsive to conditions of upland soils and cover. Its peak flow estimation techniques are appropriate for projects such as gully control, culvert sizing and forest roads, environmental impact analyses, and post-wildfire hydrologic response.

The software program and user manual were written by Richard H. Hawkins (professor emeritus, University of Arizona, Department of Agricultural and Biosystems Engineering and Department of Hydrology and Water Resources) and Armando Barreto-Munoz (research assistant, University of Arizona, Department of Agricultural and Biosystems Engineering).

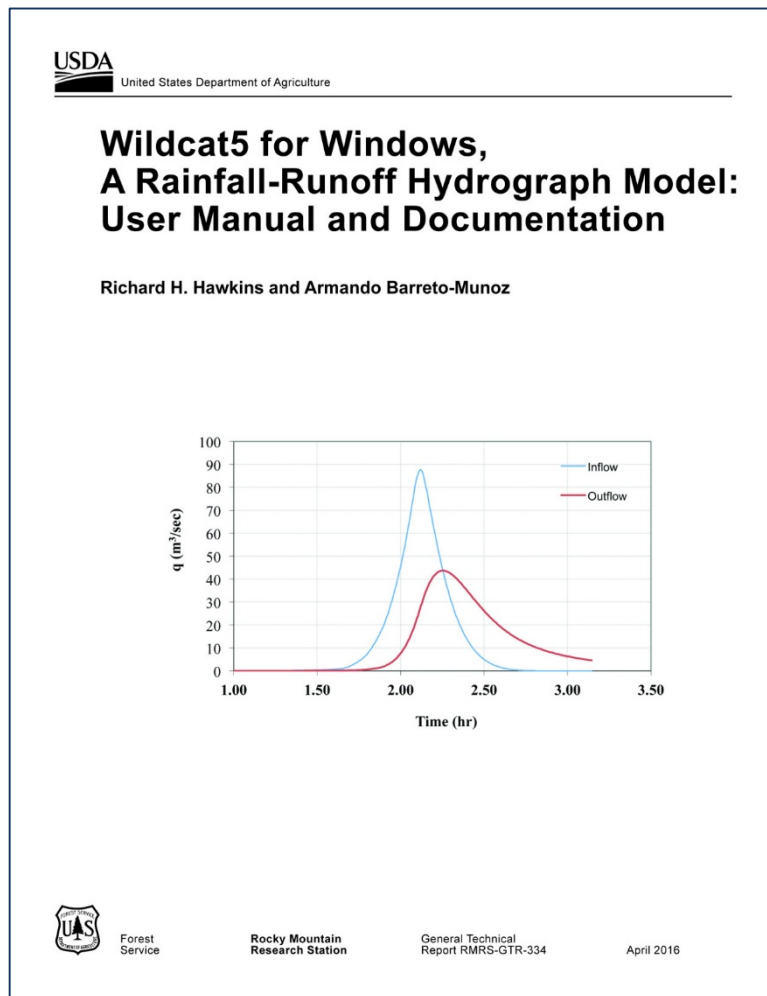
The user manual provides step-by-step instructions for using the software and is organized in the same logical fashion in which the data are entered when using the program. Model inputs are

rainstorm characteristics, parameters related to watershed soil and cover, runoff timing parameters, and unit hydrograph shape and scale selections. Many choices are available for each of the input categories and guidance is provided for their appropriate selection. The software and user manual also includes an example for ready use of the program. Additionally, the user manual describes the fundamental concepts, capabilities, limitations, features, input requirements, and output of Wildcat5.

Electronic copies of the Wildcat5 user manual and software, can be downloaded from the [NSAEC tools webpage](#). Additionally, the GTR is available through the [RMRS GTR-](#)

[334 download page](#). This software and publication may be updated as features and modeling capabilities are added to the program. Users should periodically check the download site for the latest updates.

Errors of omission, logic, or miscalculation should be brought to the attention of the authors or the National Stream and Aquatic Ecology Center. Wildcat5 is supported by, and limited technical support is available from the U.S. Forest Service, National Stream and Aquatic Ecology Center. A limited number of hard copies are available and can be requested by contacting [Dan Cenderelli](#) with a subject line of “Wildcat5 publication.”



SN