USDA
United States Department of Agriculture

IN THIS ISSUE

- Effects of Historical Logging on Rivers in the Lake States
- Obituary Daniel Sarr (1964-2015)
- Notices and Technical Tips
- Geospatial Visualization Tools
- Riparian Guilds and Disturbance
- Postdoctoral Scholar Opportunity

The Technical Newsletter of the National Stream and Aquatic Ecology Center
Fort Collins, Colorado *November 2015*

Effects of Historical Logging on Rivers in the Lake States

Dale Higgins
Hydrologist

Sue Reinecke
Fisheries Biologist

Chequamegon-Nicolet National Forest

There is considerable historical significance and, in some places, nostalgia regarding historic logging and log drives. But these activities had caused substantial negative impacts to streams, creating restoration opportunities to restore ecological function. It is important for natural resource managers and the public to recognize these impacts and opportunities.

During the 19th and early 20th century, logging relied on rivers to transport logs to market throughout the Lake States. This use had a substantial impact which affects aquatic habitat to this day. Channel cleaning, building and operation of logging dams, log drives, log rollways, and timber harvesting of stream bank areas are examples of activities that impacted these stream systems.

The pineries of Michigan, Minnesota, and Wisconsin were extensively logged in the mid-late

Figure 1: Larger, permanent logging dam in the Great Lakes area.

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.

StreamNotes is produced quarterly as a service of the U.S. Forest Service National Stream and Aquatic Ecology Center (NSAEC). This technical center is a part of the Washington Office's Watershed, Fish, Wildlife, and Rare Plants program.

Editor: David Levinson

Technical Editors:
- Steven Yochum
- Brett Roper

Layout: Steven Yochum

To subscribe to email notifications, please visit the subscription link.

If you have ideas regarding specific topics or case studies, please email us at StreamNotes@fs.fed.us

Ideas and opinions expressed are not necessarily Forest Service policy. Citations, reviews, and use of trade names do not constitute endorsement by the USDA Forest Service. Click here for our nondescrimination policy.

1800's to provide wood for a rapidly expanding population in the Midwestern United States. White pine was favored for its workability and because it floated. Several factors led to the extensive harvest of these pineries, including stream networks which allowed logs to be transported to market, gentle terrain, and a winter season which allowed logging when wetlands were frozen. The logging cycle during this period included preparing rivers in summer and fall; felling trees and transporting logs to rivers in winter; and transporting logs to market in spring. While logging companies incurred costs throughout the year, they did not receive payment until logs were delivered to mills in the spring – this provided a powerful economic incentive to ensure logs could be delivered to mills. This in turn led to the thorough "cleaning" of channels to remove obstructions and the building of dams to ensure an adequate water supply for flushing the logs downstream.

Preparing Rivers for Log Driving — "River Cleaning"

Most rivers were not suitable for driving logs in their natural condition (Rector 1951). Many were too shallow and choked with brush, rocks, or fallen trees. To prepare rivers for log driving, fallen trees were removed from the channel and snags, rocks, and brush were cleared with hand tools or (later) with dynamite (Rector 1951; Benchley et al. 1993). The following account provides an example of the level of river cleaning that occurred: "In 1866 Philetus Sawyer took 'about 36 men and several teams' to the upper reaches of the Wolf River of Wisconsin where they deepened the channel, blasted rocks, closed up 'side cuts,' and built dams, wing dams, and side booms so the the loose logs would run 'during spring freshets'" (Rector 1951). Bassett (1987) reported that northern Michigan rivers had frequent occurrences of large tree bole snags that provided excellent fish habitat but these were removed during the log driving era.

The number and miles of streams used for log driving was extensive. In the St. Croix Valley alone, the length of rivers navigable for log driving was increased from 338 miles in 1849 to 820 miles by 1869 (Rector 1951). In some cases, "small almost imaginary creeks were utilized" (Rector 1951). Levis Creek in Wisconsin is an example of how far loggers ventured upstream. It was reported as a small stream that had to be cleared of stones and snags with canals cut across sharp bends, yet with these "improvements" the stream still would not float logs at ordinary stage and logging dams were necessary (Rector 1951).

Today we refer to "fallen trees" and logs as large wood. This material is recognized as critically important habitat for a variety of aquatic species in rivers and lakes (Bisson et al. 1987). Large wood provides hiding and spawning cover for fish (Angermeier and Karr 1984; Hoff 1991); alters stream current which provides resting areas, increases habitat diversity, and can expose gravel for spawning; and it serves as a stable substrate for aquatic invertbrates in shifting sandbed rivers (Benke et al. 1985). Large rocks and brush provide similar habitat. River cleaning had a profound effect on rivers, which resulted in less total aquatic habitat and reduced complexity.

Logging Dams

Logging dams covered a wide range of size, cost, and permanence. The primary purpose of dams was to store water for release during the drive and to provide log holding areas. Larger dams had control gates and sluiceways and were usually of log crib construction (Vogel 1980; Figure 1). They were used on main rivers for many years such as the Round Lake dam that operated from about 1883 to 1909 (Vogel 1980). The locations of many permanent dams are known along with the sections of river impacted. By 1890 there were 60-70 dams in the St. Croix valley, 41 in the Menominee Valley, 25 on the 95-mile long red Cedar River, nine dams on the Plate River in Minnesota, nine dams on the East Fork of the Black River, and 110 dams in the Chippewa valley (Rector 1951). Smaller, lower cost dams were also commonly used, especially in areas that would be logged out in just a few years. These included rafer, post, brush and stone, and earthern dams (Vogel 1980). Some were referred to as "splash" dams which were apparently broken or blasted to release their store of water and logs (Verry 1992). The locations and impacts from splash dams is less well known but apparently substantial.

Logging dams stored water throughout the year and released it to supplement or extend the normal spring runoff period. Drives could last a few days or up to a month and could occur from April until July if weather conditions allowed (Rucker 1999). The amount of water released varied widely depending on the storage area above the dam and the size of the watershed. Five dams located on small tributaries of the Snake River of Minnesota provided from one to six days of driving water when opened (Rector 1951). Twelve other dams in the St. Croix basin provided 1 to 10 days of driving water – one alone could raise the St. Croix River one foot 50 miles downstream. Another took eleven months to raise a six-foot head but provided 20 days driving water (Rector 1951). The Namekagon

and Totagatic Log Company built a dam in 1869 that was 12 feet high and 400 feet long. It took eleven months to fill to a head of six feet but provided 20 days of effective driving water (Rector 1951).

Based on poplar descriptions of log driving and historical photos, it is likely that during much of a log drive, the flow equaled or exceeded the capacity of the channel. One indication of this is the frequent description of logs being lost or stranded in flooded areas along the river (Rector 1951; Figure 2). The process of river drivers pursuing stray logs and bringing them back to the main channel was a common enough occurrence that it was given its own name known as "sacking." Log drivers in the process of "sacking" have been recorded in historic photos. For example, the Round Lake logging dam was located at the head of the South Fork Flambeau River at the outlet of the Round Lake Chain. The dam had two 15-foot gates and one 10-foot gate with an operating head of 8-10 feet (Vogel 1980) which provided up to 16,000 acre-feet of water storage. This would be sufficient to create flows greater than bankfull for more than a month (Figure 3).

Figure 2: Log drive, with many logs stranded on the banks (Minnesota Historical Society).

In addition to the controlled release of water, larger floods were also caused by logging dam failures, a number of which are documented in the historic record. The Fox dam on the Pine River in Wisconsin failed in 1891, ten dams washed out in Minnesota in 1896, a section of a dam on the Moose River washed out in 1888, a large dam at Menominee was destroyed by a flood in June of 1888, and part of a dam near Clearwater Lake Minnesota failed in 1888 (Rector 1951). Four dams washed out in McCaslin Brook in December 1884. John Nelligan described the resulting flood as carrying everything in front of it, uprooting and snapping off trees and washing away the banks (Rucker 1999). These accounts indicate logging dam failures were a common occurrence that caused significant floods and likely caused geomorphic change in the form of scoured channels and eroded streambanks.

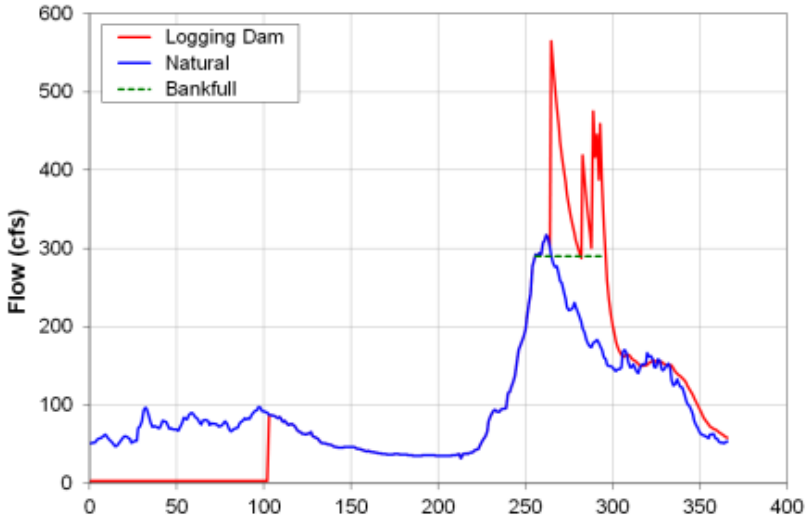


Figure 3: Estimated average daily flow impact of Round Lake logging dam on South Fork Flambeau River flows (data source: S.F. Flambeau River near Phillips, WI streamgage, USGS 05359500)

Impacts

The operation of logging dams generally created floods that equaled or exceeded the channel capacity for an extended period of time each spring and summer. This time period likely ranged from a few days to a month or more. Both the controlled release of water from logging dams and the failure of some dams resulted in flood flow amounts and durations that exceeded what would have happened under normal conditions. These flows alone had the potential to alter channel characteristics. In addition, sediment from channel scour, streambank erosion or other logging activities would have

increased the potential for channel changes.

Streams form and maintain their channel and floodplain in response to water and sediment that are delivered from upstream. River channels tend to be sensitive to changes in either of these inputs (Leopold 1994). Increasing the magnitude or duration of floods can lead to adjustment of channel characteristics with channel widening being the most common response (Verry 2000). This leads to higher width/depth ratios which, in turn, tends to provide poorer aquatic habitat. Increased sedimentation can have a similar effect.

It is likely that the release of water during log drives increased the frequency and duration of flood flows sufficiently to cause channel widening in many streams. This is supported by observations of engineers and lumberman who reported that the use of dams made streams less suitable for log navigation because continual releases of water from the dams caused the rivers to become wider and shallower (Rector 1951). Less frequent but more extreme floods caused by dam failures would have aggravated this effect on some rivers.

Riparian-Bank Effects: Log Rollways and Timber Harvest

Most nineteenth century logging occurred during winter when logs could be transported over snow and ice to the rivers. Some logs were stored directly on the ice of frozen lakes and rivers. Logs stored on river banks were stacked so they could be released and rolled into the river channel.

High, steep banks, usually on outside bends where hydraulic erosional forces are greatest, were favored locations for log rollways (Figure 4). The removal of all trees and brush and subsequent rolling of logs caused substantial bank erosion at these sites. Many log rollways have become partially or completely revegetated over time but others have continued to erode to this day, particularly those with high, steep, non-cohesive sand banks. Sediment from increased streambank erosion tends to make channels wider and shallower. Trees harvested from log rollways or other banks would also have eliminated future sources of large wood to streams.

Figure 4: Typical log rollway.

Management Implications

- Historic logging and log drives impacted rivers in the Lake States, causing wider, shallower channels and reduced habitat complexity.
- Opportunities exist to restore habitat through instream restoration of channel morphology, replacement of wood and rock habitat, and restoration of riparian forests.

References

Angermeier, P.L. and J.R. Karr, 1984. Relationships between Woody Debris and Fish habitat in a Small Warmwater Stream. Transactions of the American Fisheries Society 113:716-726.

Bassett, C.E., 1987. Rivers of Sand: Restoration of Fish Habitat on the Hiawatha National Forest. In: Proceedings of the Society of American Foresters national convention, Minneapolis, MN, Oct. 18-21, 1987, Society of American Foresters, Bethesda, MD, 116-120.

Benchley, E.D., F.A. Copes, M.F. Kolb, N.P. Lasca, P.J. Porubcan, K. J. Schabel and L.G. Whitman, 1993. Investigation of the Influence of Late 19th – Early 20th Century Logging on Fluvial Geomorphology and Fisheries Habitat on the Indian River, Hiawatha National Forest, Michigan. Prepared for US Forest Service, Hiawatha National Forest, Report of Investigations No. 113, Archaeological Research Laboratory, University of Wisconsin-Milwaukee. 219 p.

Benke, A.C., R.L. Henry III, D.M. Gillespie, and R.J. Hunter, 1985. Importance of Snag Habitat for

Animal Production in Southeastern Streams. Fisheries 10(5):8-13.

Bisson, P.A., R.E. Bilby, M.D. Bryant, C.A. Dolloff, G.B. Grette, R.A. House, M.L. Murphy, K.V. Koski, and J.R. Sedell. 1987. Large woody debris in forested streams of the Pacific Northwest: past, present and future. Pages 143-190 In E. O. Salo and T. W. Cundy, editors. Proceedings of a Symposium on Forestry/Fishery Interactions, Contribution Number 57, University of Washington, Seattle, Washington, USA.

Hoff, M.H., 1991. Effects of increased nesting cover on nesting and reproduction of smallmouth bass in northern Wisconsin. Pages 39–43 in D. C. Jackson, editor. Proceedings of the first international smallmouth bass symposium. Mississippi State University, Starkville.

Leopold, L., 1994. A View of the River. Harvard University Press, Cambridge, Massachucettes. 298 p.

Rector, W.G. 1951. The Development of Log Transportation in the Lake States Lumber Industry 1840-1918. Ph. D. Thesis, University of Minneasota. 371 p.

Rucker, D. 1999. From the McCauslin to Jab Switch, A History of Logging in Oconto County. Oconto County Economic Development Corporation, P.O. Box 43, Oconto, Wisconsin, 54153. 106 p.

Verry, E.S., 2000. Water Flow in Soils and Streams: Sustaining Hydrologic Function. In: Riparian Management in Forests of the Continental Eastern United States, Edited by E. S. Verry, J. W. Hornbeck and C. A. Dolloff, CRC Press LLC, Boca Raton, FL.

Verry, E.S., 1992. Riparian Systems and Management. In: Proceeding Forest Practices and Water Quality Workshop, Lakes States Forestry Alliance, Green Bay, WI.

Vogel, J.N., 1980. Folk Technology: A History of the Round Lake Logging Dam. Unpublished Report, Chequamegon National Forest, Park Falls, WI. 34 p.

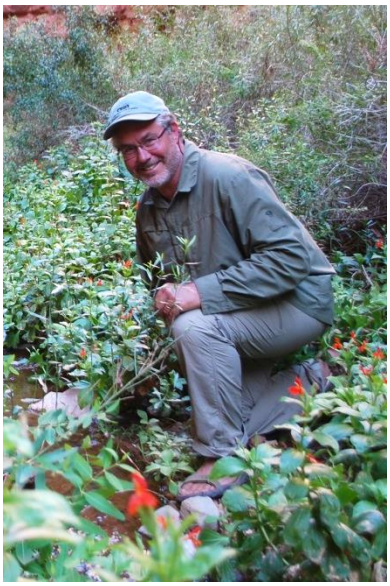
Obituary Daniel Sarr (1964-2015)

It is with great sadness that we report the passing of our colleague Dr. Daniel Sarr, who died while hiking in a remote and rugged area of the eastern Grand Canyon National Park in August, 2015. He was participating in a study of riparian plant ecology along the Colorado River with the US Geological Survey Grand Canyon Monitoring and Research Center, Flagstaff, Arizona. Daniel was an ecologist with the USGS and an Adjunct Professor of Forestry at Northern Arizona University.

Daniel is survived by his wife, Jocelyn O'Neill and son, Liam O'Neill Sarr.

Daniel was born on March 13, 1964 in San Jose, California, graduated from Humboldt State University with a B.S. degree in Biology in 1989, and received his M.A. from the University of California, Santa Barbara in 1995 in Aquatic and Population Biology. In 2005, Daniel earned a Ph.D. in Forest Science from Oregon State University.

Daniel served as Supervisory Ecologist-Program Manager for the



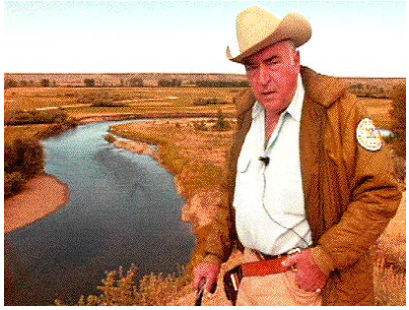
Klamath Network-National Park Service in Ashland, Oregon for 13 years during which time he received a Fulbright Fellowship for studies at the National University of Ireland in 2008. One of Daniel's many professional accomplishments was to develop a monitoring and management plan for the National Parks of northern California and southern Oregon. This plan was of national significance and earned Daniel a National Park Service Superior Performance award in 2011. Over the past year Daniel had partnered with the National Stream and Aquatic Ecology Center on the modeling of riparian vegetation guilds in the Grand Canyon.

Daniel's good humor, endless curiosity, focused thinking, and creative views about nature, history, and geography led him to make several significant contributions to the ecological literature and earned him the respect of colleagues worldwide.

In addition to his professional accomplishments, Daniel was known by all as a kind-hearted, enthusiastic, creative man, a friend, and committed son, brother, husband, and father. He will be greatly missed.

As one colleague remarked upon hearing of this tragedy, "there is no positive, but at least he died in a beautiful place doing something he loved." Another colleague from Portugal said that she would never forget Daniel's smile and that she felt "saudades." Another colleague said, "It was clear from our short time together (at a professional meeting) what a big, generous spirit Daniel had, I feel honored to have known him." The most common response from the scientific community was "shock" at the news. It is clear that Daniel touched many with his inquisitive nature and scientific curiosity.

Notices and Technical Tips



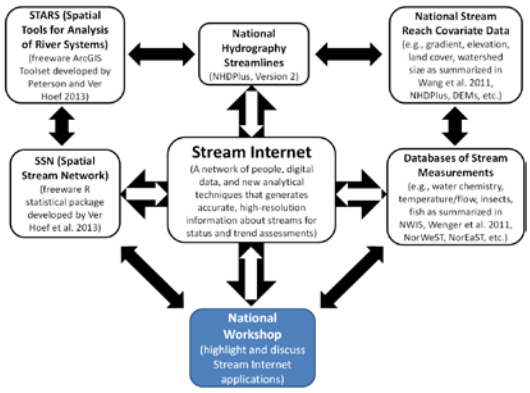
- Lessons Learned from a Legend: Luna Leopold's View of the River
  A USGS blog, Coyote Gulch, published a feature (by Curt Meine) on Luna Leopold. The following is an excerpt:

  "Born on Oct. 8, 1915 in Albuquerque, Luna Leopold lived a rich life. From his renowned father, the biologist and author Aldo Leopold, he inherited a passion for outdoor life, a respect of craftsmanship, a highly disciplined curiosity, and an appreciation of the complex interactions of human society and natural systems. From his mother Estella, he inherited a deep connection to the semi-arid landscapes and watersheds of the American Southwest, a rich Hispanic cultural tradition, and a keen aesthetic sense. These qualities would meld and develop over time, across an extraordinary career in the earth sciences."

- Environmental Outlook: Lessons Learned from Israel's Search for Water A WAMU Diane Rehm Show feature on how Israel addresses water scarcity:

  "California is in its fourth year of record-breaking drought. Yet, the Golden State is far from alone in its water woes. Forty of 50 U.S. states will face shortages within the next decade. A fifth of the world's population already experiences scarcity. Yet, some say solutions do exist to blunt the worst effects of this growing problem. They point to Israel. The desert country struggled with supply since its creation, leading to extreme conservation and controversy with neighbors. A drought last decade pushed Israel to seek more comprehensive water solutions."

- Stream buffer benefits along headwater channels have been investigated by Dede Olson and her team with the Pacific Northwest Research Station, and in collaboration with the Oregon State University, Bureau of Land Management, and U.S. Geological Survey. As presented in a Science Findings report, it was found that "aquatic and riparian species and habitat were retained with no-entry, 50-foot minimum variable-width buffers." For more information, refer to the PNW Science Findings report.



- The National Stream Internet project has been developed to provide a national analytical infrastructure for stream data that can be applied consistently throughout the country. It leverages existing water quality data, biological surveys, and habitat condition assessments collected by federal, state, tribal, and private organizations to assess status and trends. For more information, visit the project website or the RMRS Science Briefing.

- The National Forest Service Library focused on Water and Aquatics in October, linking Forest Service staff with such products as Water Resource Abstracts. Keep in mind the services offered by the National Forest Service Library, including monthly alerts to help with professional development, managements alerts with articles of interest to line officers, and more.

- Have you been in the field observing flood debris deposited from a recent event and have been curious about what the flood looked like at the time? A video published by David Rankin helps us understand such flash floods. It was shot in part using a drone. This event occurred in Southern Utah, reportedly in Kane County on August 30th.

Geospatial Visualization Tools for Understanding Environmental Complexities

Greg Dobson
Research Scientist

James Fox
Director

University of North Carolina at Asheville, National Environmental Modeling and Analysis Center

Decision makers are tasked to deal with complex systems that are typically comprised of multiple factors. Hazards such as drought, wildfire, heavy rain, and floods can negatively impact an array of environmental ecosystems. Forest, water, and other land managers, as well as many other decision makers, need effective and useful tools to address these complex systems. Unfortunately, stakeholders and decision makers often don't have the tools they need to better understand these multi-faceted complex systems.

The University of North Carolina at Asheville's National Environmental Modeling and Analysis Center (NEMAC) has spent the last decade collaborating with many organizations, including the U.S. Forest Service, the NOAA National Center for Environmental Information, the NOAA National Weather Service, as well as state and regional climate centers and other local groups to integrate weather, climate, hydrologic, and other data into meaningful and actionable information assessable though geospatial visualization tools. By working with these and other groups, NEMAC seeks to facilitate decision making processes between the non-scientific community, weather forecasters, forest and land managers, hydrologists, and climate scientists concerning topics such as floodplain management, prescribed fire, weather-related hazard mitigation, climate change, and societal impacts.

Geospatial Visualization Tools

The use of geospatial visualization tools to address complex systems has become increasingly common over the last 15 years. They are well-suited to consider the diversity of stakeholder values, trusted sources of information, data uncertainty, geographic scale, and the display of a range of predicted outcomes through scenario planning. Decision makers require more than just raw data to make accurately informed decisions; they need complete integrated data solutions. However, much of these data are not easily accessed or are in formats that are difficult to interpret. By integrating trusted sources of weather, climate, and water information with other geographic datasets (e.g. economic, environmental, infrastructure, cadastral, terrestrial), geospatial visualization tools can be created to enhance and facilitate science and risk communication.

Geospatial visualization tools refer to many different types of spatial or GIS-based applications, including 2D map viewers, interactive graphics, static maps, smart apps, 3D animations, outreach videos, innovative displays such as touch screens and immersive geodomes, and gaming platforms. They typically vary in design and appearance, and have a wide-range of application, power, and mobility. There are proprietary and open source solutions for developing geospatial visualization tools. Both have their advantages and disadvantages and it is important to assess the customer's needs, customization requirements, platform use, and whether the project requires analyses using 2D or 3D tools (Dobson 2010).

2D Geospatial Visualization Tools

NEMAC has developed custom 2D geospatial visualization tools to address such issues as forest health, flood concerns and other natural hazards, climate variability and change, among others. One such tool combines hazard-related data layers including floodplain, landslide, dam failure, wildfire, and others in an integrated application that allows users to assess the impacts from such hazards individually or in combination with other information. The "multi-hazard risk tool" not only displays spatial data, but it also links the data to risk and exposure.

Another 2D geospatial visualization developed by NEMAC for the U.S. Forest Service is ForWarn and its accompanying Forest Change Assessment Viewer (FCAV). ForWarn provides near-real-time tracking of vegetation changes across landscapes in the United States. Useful for both monitoring disturbance events as well as year-to-year variability, derived products can also be used to develop insights into seasonal and inter-annual dynamics. The FCAV provides a vegetation change recognition and tracking system for ForWarn that uses high-frequency, moderate resolution MODIS (Moderate Resolution Imaging Spectroradiometer) satellite data. Maps generated from the FCAV show the effects of disturbances such as wildfires, wind storms, insects, diseases, and human-induced disturbances in addition to departures from normal seasonal "greenness" caused by weather. Using this state-of-the-art tracking system, it is also possible to monitor post-disturbance recovery and the cumulative effects of multiple disturbances over time.

A unique component of ForWarn and other geospatial visualization tools that NEMAC has developed is Multigraph. a JavaScript framework for creating 2D data graphs for the web. It can read data in a variety of formats and is highly customizable. Multigraph allows users to explore timer series data such as precipitation and temperature within an interactive graph, allowing the X, Y, and Z axis to be fully controlled.

3D Geospatial Visualization Tools

Decision makers, land managers, and others often have a difficult time interpreting 2D maps and ascertaining much useful information from them. However, by presenting the same information using 3D data displays, this same information can become much more meaningful and actionable to stakeholders.

The 3D geospatial visualization process begins with data assembly and creation. Depending on the scale and amount of detail that is desired for the 3D geospatial visualizations, there are four main categories of data layers that are required including 1) high resolution imagery, 2) high resolution terrain or digital elevation models, 3) 3D building and tree/vegetation models, and 4) overlay of a specific layer of interest, such as floodplains or flood models, fire scars or burn areas, slope and contour data, drought or rainfall data, among many others. Other ancillary data such as transportation networks, infrastructure, land use, and key points of interest may also be included.

When designing 3D geospatial visualization tools, NEMAC relies primarily on the Environmental Systems Research Institute (Esri) suite products, including 3D Analyst (ArcGlobe and ArcScene), ArcGIS Pro, and ArcGIS Online. A variety of tools can be created, including static graphics, animated movies, and interactive web scenes However, a disadvantage of 3D movie files is that they force the decision maker or other user to only view what the author has decided to let them view. Another option is to create interactive web scenes and share them via the internet dynamically. Web scenes allow the user to explore the "scene" on their own using basic navigational controls for zooming, panning, and rotating the scene, and they allow the user to toggle layers on and off thus completely controlling what is visible within the scene.

Case Study 1: The Upper Swannanoa Watershed in Western North Carolina

The Swannanoa watershed (Figure 5) is located in the Southern Appalachian Mountains of Western North Carolina. It has a drainage area of 130 square miles and elevations ranging from 2,000-6,000 feet. A rural landscape of steep terrain and protected dense forested lands dominate the upper portion of the watershed while a more urban and suburban environment and flatter terrain make up the lower portion. The watershed serves as the main source of drinking water for the City of Asheville and Buncombe County, North Carolina via the North Fork Reservoir, which is located within a restricted sub-basin. The North Fork Reservoir serves dual purposes of providing drinking water and flood mitigation. The two main natural hazard-related concerns for the Swannanoa watershed are wildfires and floods, both of which have a long historical record of occurrence and have occurred within recent years.

In 2004 two major flood events impacted the watershed during a two week span causing $200 million in economic losses. Both of these events were due to the remnants of tropical systems tracking out of the Gulf of Mexico and directly over Western North Carolina, and one of these systems was responsible for close to 20 inches of rainfall in a 24 hour period. The North Fork Reservoir was quickly pushed to its limits in

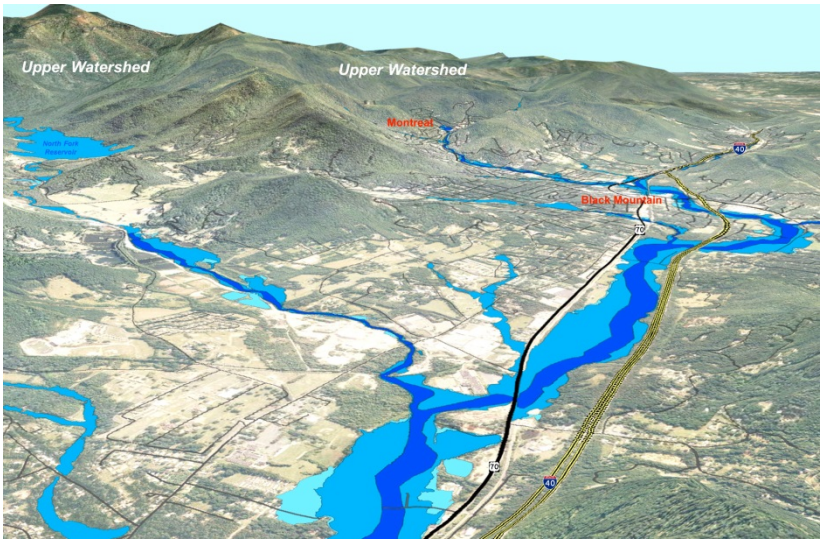


Figure 5: 3D perspective of the Swannanoa Watershed in Western North Carolina. In blue are two different versions (old and new) of floodplain data, with the floodway overlaid in the darkest blue. The North Fork Reservoir and upper watershed are visible in the background.

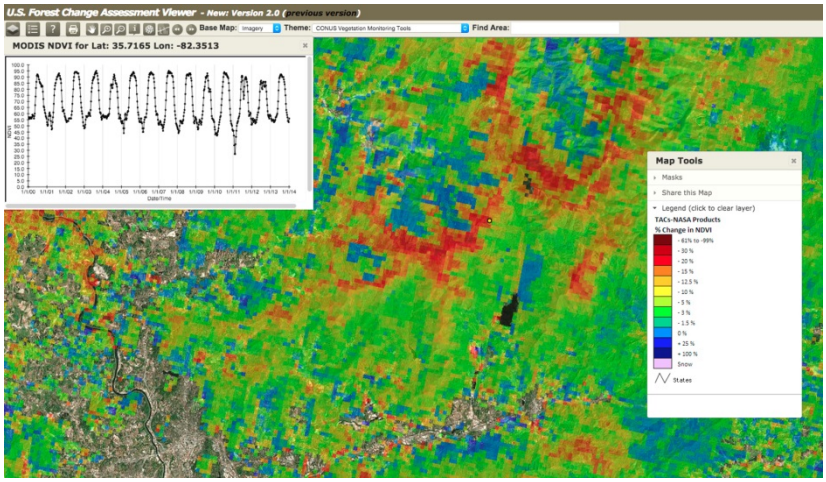


Figure 6: Screenshot of the ForWarn application. The area includes the upper Swannanoa Watershed in Western North Carolina. The color ramp is percent change of NDVI. The areas in red indicate that NDVI values have decreased since the last MODIS image date. The graph in the upper left is Multigraph displaying time series data of forest health for comparison.

terms of flood mitigation and the emergency gates were opened with little warning downstream. The resulting flood severed the main water line connecting the reservoir and the communities below, leaving 80,000 people without drinking water for three days. Further downstream major flood damage occurred in a prominent shopping and tourism district of Asheville (USGS 2005), which left roads impassable, some buildings completely destroyed, and a large loss of economic revenues.

Following the flood events area leaders, decision makers, and stakeholders formed the Flood Damage Reduction Task Force, and the group turned to NEMAC to provide innovative tools to help them understand the linkages between steep terrain, heavy rain, and flooding. A variety of geospatial visualizations tools were created to assist post-flood efforts, which included online and interactive multi-hazard GIS applications, 3D posters and movies, touch screen and visualization wall displays, and immersive experiences through immersive geodomes. Providing tools that were 3D GIS-based proved to be the most effective, and NEMAC created an entire series of virtual "fly-throughs" that simulated the flood events, presented various flood scenarios, and compared old and new floodplain maps (Fox et al. 2008).

In the spring of 2015 a large wildfire impacted a sub-basin adjacent to the North Fork Reservoir. The water manager for the City of Asheville immediately began asking how likely it would be for this to occur in the North Fork Reservoir sub-basin. A combination of geospatial visualization tools allowed for this assessment. Since the Swannanoa Watershed had already been modeled for flood mitigation following the 2004 floods (Figure 6), this information was integrated into a multi-hazard risk tool application to better understand risk exposure and vulnerabilities. The ForWarn tool allowed for the analysis of the burned areas, linking them to the hydrology information.

Case Study 2: The Colorado Front Range

Colorado's Front Range region extends roughly from Colorado Springs north to the Wyoming border, and west to the Continental Divide. Generally speaking, this region is the eastern edge of the Rocky Mountains in Colorado, with elevations ranging from 5,000 to over 14,000 feet. Just to the east of the Front Range lies a large urban corridor which contains most of Colorado's population and major cities. Streams within the Front Range flow east into the urban corridor (Figure 7), posing a substantial flood risk to populations centers when heavy rains occur. These mountains are also prone to wildfires, especially during times of drought. When heavy rains fall on these burned slopes, flooding and landslides are exacerbated.

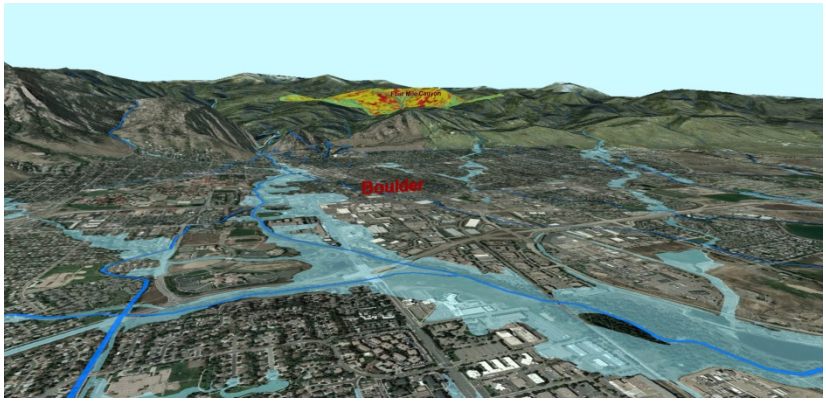


Figure 7: 3D perspective of the Colorado Front Range and foothills region over Boulder. In the background is the burn scar intensity of the Four Mile Canyon wildfire (2010). The transparent blue areas are the 100 year floodplain extents.

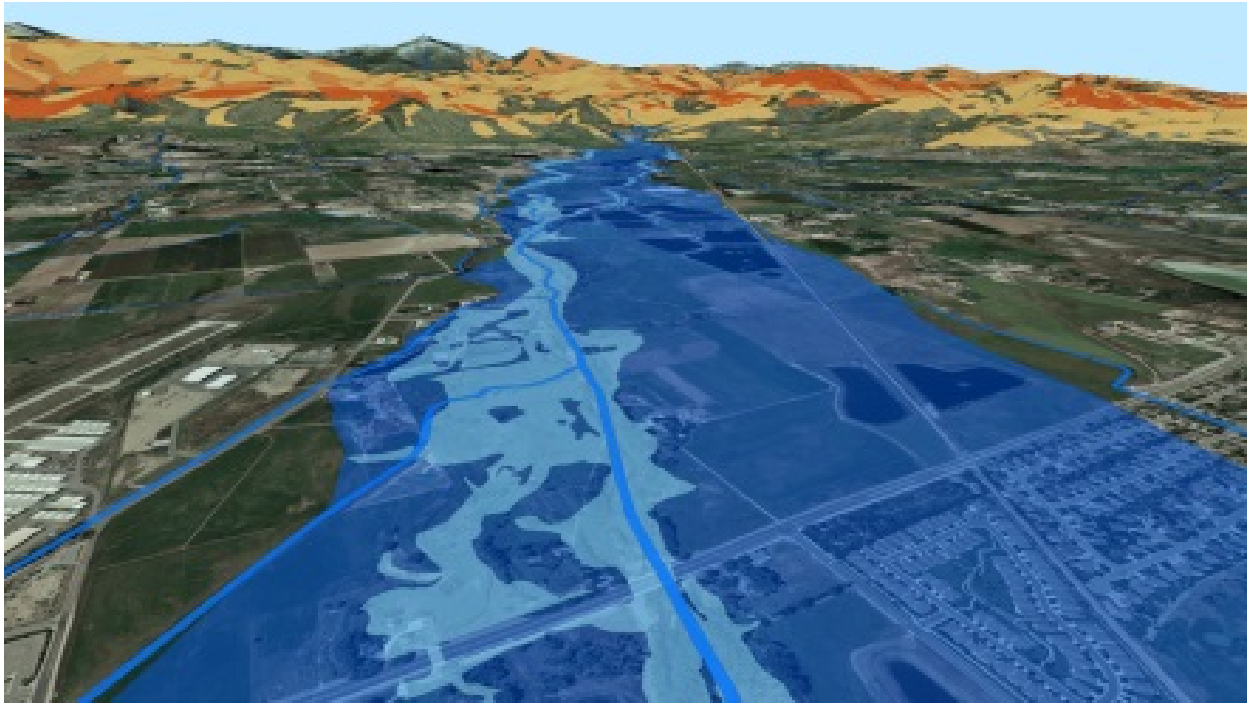


Figure 8: 3D perspective of the Colorado Front Range region near Lyons. In the background is a wildfire risk dataset shown in shades of orange. The transparent blue areas along the St. Vrain Creek are the 100 year floodplain (light blue), while the transparent dark blue areas are the observed flood extents from the September 2013 flood.

Major wildfires impacted much of the Colorado Front Range region in 2010 and again in 2012 and 2013. In September 2013 extensive flooding occurred by a large swath of heavy rainfall accumulations in the Front Range foothills, including some record totals. The extent of the infrastructure and economic loss was unprecedented. To better visualize the local hydrology and burn scar areas, NEMAC developed a 3D geospatial visualization of the Front Range region from the Boulder area north to Ft. Collins highlighting key river basins and previous wildfire areas (Figures 7 and 8).

Additional Information

For additional information regarding NEMAC and the projects and products, please refer to the following:

- UNC Asheville's National Environmental Modeling and Analysis Center
- ForWarn Satellite-Based Change Recognition and Tracking
- NEMAC's YouTube Channel Including 3D movie animations of the Colorado Front Range region, and the Swannanoa Watershed

Management Implications

- Geospatial visualization tools can provide great value to decision makers and other stakeholders tasked with addressing a range of environmentally complex issues, including forest and watershed management, weather- and climate-related natural hazards, and societal impacts.
- The use of 3D vsualization tools can help make spatially-based scientific information that is often difficult to understand much more meaningful and actionable.

References

Dobson, J.G., 2010. Using Geospatial Visualization to Facilitate Weather and Water Communication. Weather and Society Watch newsletter 4(3): 2, 8-9.

Fox, J.F., J.G. Dobson, M. Phillips, T. Pierce, 2008. Visualization as a Decision Support Tool – Asheville's North Fork Reservoir (Buncombe County, North Carolina) and the Balance between Drought and Flood Mitigation. Proceedings from the 2008 Southeast Regional Conference of the Association of State Dam Safety Officials, April 2008, Asheville, North Carolina.

United State Geological Survey, 2005. USGS Continues to Analyze the Flooding Effects from Hurricanes Frances and Ivan in Western North Carolina, 2004.

Riparian Guilds and Disturbance

Nate Hough-Snee
PhD Candidate in Riparian Ecology, Utah State University

Several years ago David Merritt, riparian ecologist with the US Forest Service National Stream and Aquatic Ecology Center (NSAEC), and others, presented the concept of riparian vegetation-flow response guilds to the StreamNotes readership (Merritt et al. 2009; discussed at length in Merritt et al. 2010). The riparian vegetation-flow response guilds concept (herein flow guilds) links plant species that occur alongside streams to instream flow. These flow metrics can include the depth, duration, and magnitude of floods that transport sediment, disturb vegetation, and disperse plant seeds and other propagules, and also the summer low flow discharge required to support riparian vegetation. By pairing vegetation species data with species' attributes that link them to flow, groups of species (i.e. guilds) with different hydrologic affinities (e.g. mesic guilds vs. xeric guilds) can be modeled in response to future water management activities like dam releases, water diversion, or climate change. These models can be used by watershed and water resource managers as a decision-making tool when planning future land- and water-use projects.

A recent article in the Ecological Society of America's *Ecosphere*, "Multi-Scale Environmental Filters and Niche Partitioning Govern the Distributions of Riparian Vegetation Guilds" (Hough-Snee et al. 2015), highlights how the riparian flow guilds concept has been applied to unregulated, wadeable streams of the Pacific Northwest, including portions of USFS Regions 1, 4, and 6. This publication was coauthored by NSEAC scientists David Merritt and Brett Roper, among others. This research applied the framework of Merritt et al. (2009, 2010) to delineate guilds based on their capacity to respond to hydrologic variability, but also incorporates watershed disturbances like fire, grazing, climate, and channel form into the grouping of species into guilds. In this research, the team identified five riparian guilds, each of which had a distinct life history strategy that corresponded to different sets of environmental filters – disturbances and resources that shape how each guild persists and expands – on the landscape. Some guilds were more linked to regional climate, while others were linked to grazing or wildfire disturbance. Additionally, guilds with different life history strategies coexisted based on their species' capacity to respond to different filters. By identifying riparian vegetation-disturbance response guilds alongside flow guilds, managers may be able to identify probable riparian vegetation responses to not only flow, but also to watershed

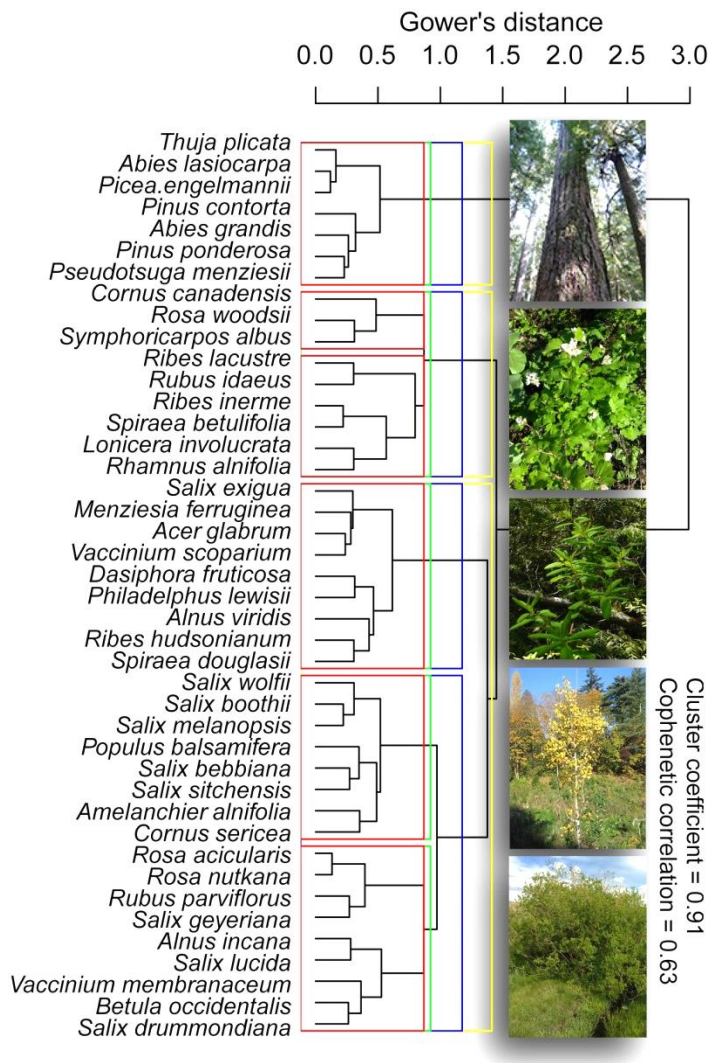


Figure 6: Groups of species with shared life-history strategies clustered into five guilds based on attributes that correspond to life form, persistence and growth, reproduction, and resource use (green colored bands), as presented in Hough-Snee et al. (2015). These included an evergreen tree guild, upland disturbance guild, mesic shrub guild, mesoriparian shrub and tree guild, and understory shrub guild.

management activities like grazing or wildfire.

The full article is available open-access from the Ecological Society of America. It is available here.

For more information on this project, contact Nate Hough-Snee, Ph.D candidate at Utah State University (nate@natehough-snee.org). For more information on the guilds framework and ongoing applications of the framework on federal public lands, contact Dr. David Merritt, Riparian Ecologist with the National Stream and Aquatic Ecology Center (dmmerritt@fs.fed.us)

Management Implications

- Changes in vegetation guilds that are linked to specific disturbances, such as water diversions, wildfire, or grazing, can be used to monitor and forecast riparian disturbance responses.
- The riparian guilds framework is complementary to existing riparian monitoring approaches that use rangeland or forest monitoring data to identify trajectories of change under current or historic land management scenarios.
- In many locations throughout the world data may exist to apply this framework to streams and riparian zones.

References

Hough-Snee, N., B.G. Laub, D.M. Merritt, A.L. Long, L.L. Nackley, B.B. Roper, and J.M. Wheaton, 2015. Multi-scale environmental filters and niche partitioning govern the distributions of riparian vegetation guilds. Ecosphere 6(10), 173, doi: 10.1890/ES15-00064.1.

Merritt, D.M., M.L. Scott, N.L. Poff, G.T. Auble, and D.A. Lytle, 2010. Theory, methods and tools for determining environmental flows for riparian vegetation: riparian vegetation-flow response guilds. Freshwater Biology 55, 206–225.

Merritt, D.M., M.L. Scott, N.L. Poff, G.T. Auble,. D.A. Lytle, 2009. Riparian Vegetation-Flow Response Guilds: A Tool for Determining Environmental Flows for Riparian Vegetation. StreamNotes, 1–8.

Postdoctoral Scholar Opportunity: Flow Regimes and Riparian Plant-Guild Population Modeling

The USDA Forest Service National Stream and Aquatic Ecology Center (NSAEC), of the Washington Office Watershed, Fish, Wildlife, Air, and Rare Plants program (WFWARP), and the Rocky Mountain Research Station seek motivated, energetic candidates for a post-doctoral position exploring how climate change will affect river flows and riparian vegetation on streams across several western US ecoregions. This position is GS 11/12 Research Ecologist in the GS-0408 job series. The position is funded for three years. Evaluation of performance occurs after 2 years, at which time the third year of funding may be renewed.

Position Description: The postdoc will help develop computer-based models that link river flow regime dynamics to population-level responses of riparian vegetation; collect and analyze field data; and write publications in collaboration with the principle investigators. The postdoc will have opportunities to work with collaborators at University of Washington (Julian Olden) and Oregon State University (Dave Lytle) and with the National Forest Service in Fort Collins (David Merritt), as well as collaborate with an interdisciplinary team at NSAEC, the Rocky Mountain Research Station, and Colorado State University. Although based in Fort Collins, CO, we will test models with data collected remotely at arid-land military bases and adjacent National Forests in California, Arizona, and Colorado. This project will complement other applied science projects being conducted at the Center, including plant trait measurement and analysis, community ecology, and management of flow regimes on regulated rivers across the country; an interest in cross-disciplinary collaboration is highly desirable.

Skills Necessary: Candidates must have a PhD in ecology or a related discipline, and solid experience with quantitative methods implemented in the R program, Mathematica, or other programming languages. Direct experience with plant distribution modeling and population-level modeling is a plus. In addition, familiarity with geographic information systems (ArcGIS), statistical analyses, and plant evolutionary ecology is a plus. Salary will be commensurate with experience. Anticipated start date is January 15, 2016 (negotiable). Apply by December 5thth, 2015 for full consideration. E-mail a letter of application, CV, and contact information for three references to: Dr. David M. Merritt (dmmerritt@fs.fed.us).

Additional information is available through the WFWARP web site.

The USDA Forest Service is an affirmative action, equal opportunity employer.

SN