



North Carolina Forest Service Bridgemat Loan & Education Service Report 2009 - 2017

**Water Resources Branch
North Carolina Forest Service
August 2018**



The N.C. Forest Service is a division of the
N.C. Department of Agriculture and Consumer Services
Steve Troxler, Commissioner



North Carolina Forest Service Bridgemat Loan & Education Service Report: 2009 - 2017

February 2019.

A.J. Lang. – Watershed and Conservation Staff Forester
Water Resources Branch
North Carolina Forest Service
N.C. Department of Agriculture & Consumer Services
1616 Mail Service Center
Raleigh, NC 27699-1600

Main Phone: (919) 857-4801

Web site: www.ncforestservation.gov

Table of Contents

Executive Summary.....	4
Forestry Bridgemat Basics	5
NCFS Loan Delivery Service.....	9
Follow-up on the 2002-2008 Bridgemat Project Status Report.....	12
Outreach and Education.....	15
Emergency Assistance Applications	16
Applied Forestry Research at Stream Crossings	17
Conclusions	18
References.....	19
Appendices	19

List of Figures

Figure 1a. A set of three bridgemats installed for a haul road crossing of a perennial stream in central North Carolina.....	5
Figure 1b. A set of two bridgemats with log stringers installed for a skid trail crossing of a stream in central North Carolina.	5
Figure 2. Two perspectives of several bridgemats spanning a road-side ditch in the Coastal Plain of North Carolina.....	5
Figure 3. NCFS bridgemats used in Edgecombe County, 2014 to protect a ditch from sedimentation.	6
Figure 4. Six different steel bridgemat design configurations observed by NCFS staff.	7
Figure 5. One steel trailer with wooden travel surface and five different wood bridgemat designs/configurations.....	8
Figure 6. Old timber bridgemats donated by NCDOT, at the NCFS Fayetteville District Office. Photo taken January 2014.....	9
Figure 7. Number of acres harvested by using 16 sets of NCFS bridgemats summarized by year.....	10
Figure 8. Number of stream crossings protected through use of 16 sets of NCFS bridgemats summarized by year.	11
Figure 9. Number of recorded loaning events for all 16 sets of NCFS bridgemats summarized by year.....	11



Figure 10. Stream crossings sites during the forest operation as published in Boggs and others (2017). A) Wood bridgemats on temporary skid trail, B) Steel bridgemats on a temporary skid trail, C) Steel bridgemats on a temporary skid trail, D) Wood bridgemats on temporary skid trail, E) 30-inch diameter culvert on a permanent haul road, and F) Steel bridgemats on a permanent haul road. 13

Figure 11. A) Installation of treated Emtex™ wooden bridgemat panels over Purlear Creek, B) Metal end-cap securing wooden panels to the concrete abutment, C) Cross decking installed atop the initial bridgemat paneling. D) Completed installation of the demonstration bridge. 14

Figure 12. Signage depicting the Purlear creek bridgemat crossing on display at Rendezvous Mountain Educational State Forest..... 15

Figure 13. Wayne Community College (left) and North Carolina State University (right) students participating in the NCFS led stream crossing scenrio exercise. 15

Figure 14. Attendees at two of the eight water quality refresher workshops in 2017. 15

Figure 15. July 2013, NCFS Asheville District’s bridgemats being installed for public road access after flooding in Madison County, NC. The bridgemats provided homeowners access to their homes until the crossing could be repaired. 16

Figure 16. September 2016, NCFS Hillsborough District’s bridgemats installed for public road access following Hurricane Matthew in Alamance County, NC. This temporary fix provided access to dozens of homes and was highlighted by local television media. 16

Figure 17. November 2017, NCFS Asheville District’s bridgemats were installed following severe storms caused damage to a low-water crossing in Buncombe County, NC. NCFS Bridgemats were placed about 30-ft upstream and served as the primary access to several homes until the crossing was repaired. 16

Multiple photos illustrating different applications of bridgemats across North CarolinaFront & Rear Cover



Executive Summary

This report provides an update to the N.C. Forest Service's (NCFS) Bridgemat Loan & Education Service with a focus on the 2009 to 2017 period. The report contains information on the basics of bridgemats, a summary of NCFS loan events and southeastern U.S. research studies involving bridgemats.

State forestry agencies across the southeastern United States caution loggers that stream crossings are one of the more vulnerable locations for water quality risks. Observations by N.C. Forest Service (NCFS) field staff in the 1990's suggested that bridgemats could have been implemented more frequently at stream crossings where site conditions were suitable. The suspected reason for infrequent bridgemat implementation was generally thought to be a lack of awareness and information on how to properly use bridgemats.

Forestry researchers have evaluated water quality parameters prior to, during and post installation of several stream crossing types. They generally conclude that each crossing method (ford, culvert, bridge) can effectively protect water quality levels when installed where site characteristics are appropriate and implemented with judicious best management practices (BMPs). However, researchers also report operational advantages and minimized environmental risks associated with bridgemat options for temporary crossing solutions.

To showcase bridgemats as a viable stream crossing option, the NCFS purchased wooden bridgemats in the early to mid-1990s and loaned them to loggers. In the early 2000s, this service was revitalized with the purchase of steel bridgemats and was rebranded as the Bridgemat Loan & Education Service. This enhanced service was made possible through Clean Water Act funding (Section 319h) granted by the U.S. Environmental Protection Agency and the Albemarle-Pamlico National Estuary Program. The intention of the program was to introduce bridgemats to forest operators across North Carolina by allowing them to borrow NCFS owned bridgemats free of cost. This service provided an additional avenue to communicate with loggers and allowed them to test bridgemats without an initial investment. NCFS hoped that borrowers who experienced the ease of installation, use and removal process would recognize the potential for long-term financial benefits and be convinced to buy their own bridgemat sets.

The NCFS has primarily lent bridgemats to loggers, but has also loaned them to natural resource managers and other forestry professionals for more than 15 years. Between 2003 and 2017, documented loan events of NCFS owned bridgemats were used on 736 logging jobs to establish 824 stream or ditch crossings, and provided access to over 31,000 acres of timberland. Occasionally, NCFS owned bridgemats are used for emergency response situations, which are also detailed in this report for the 2009-2017 period.

Compared to loan numbers in the previous 2002 to 2008 bridgemat report, the overall average number of NCFS bridgemat loan events has increased by 21percent. However, an evaluation of the loaning records and communication with NCFS staff suggests a narrowing and repetitive customer base. As this service is continued, funding will be needed to replace age-worn bridgemats. All wooden and some steel bridgemats owned by the NCFS have been retired from the loaning service. Some steel bridgemats have been maintained and remain available for loan. Future program service is continually under evaluation but will remain functional until all bridgemats are retired.

Previous reports on the NCFS Bridgemat and Education Loan Service and additional information can be located on the NCFS website.



Forestry Bridgemat Basics

What Are Forestry Bridgemats?

The word 'bridgemat' is used to describe a heavy wooden timber or fabricated steel panel that can be situated across a stream or ditch channel to serve as a temporary bridge for access by logging equipment during forest harvesting activities. Other known terms used included: dragline mat, logging mat, skidder bridge, pontoon bridge, or bridge mat (two words). For videos on forestry stream crossings with bridgemats and other BMP videos, please visit: https://www.ncforests.com/water_quality/video_series.htm.

How Are Bridgemats Used?

Typically, individual bridgemat panels (4-ft wide) are installed across a channel using a grapple skidder or by winching the panels into place with a skidder or crawler tractor. Bridgemat panels butted next to one another help prevent loose soil, tree limbs and other logging debris from dropping into the channel during equipment travel. These single span structures often provide temporary access for main skidding trails or haul roads (Figure 1a,b). Some forest operators choose to use two panels where machinery tires will travel and log stringers in the center to reduce costs associated with an additional panel (Figure 1b). Multiple panels are used compared to one large structure to provide easier staging and reduce transportation width. Installing three 4-ft panels tightly against each other provides a sufficient pathway for most forest machinery. However, several bridgemats are frequently used in the Coastal Plain region at log decks to span an adjacent road ditch or canal. These additional panels provide necessary space for turning semi-trailer log trucks (Figure 2).



Figure 1a: A set of three bridgemats installed for a haul road crossing of a perennial stream in central North Carolina.



Figure 1b: A set of two bridgemats with log stringers installed for a skid trail crossing of a stream in central North Carolina.



Figure 2: Two perspectives of several bridgemats spanning a road-side ditch in the Coastal Plain of North Carolina



Why Use Bridgemats?

Some benefits of using bridgemats as a temporary crossing instead of culverts or fords include (in no order):

- Can be installed with common logging equipment (grapple skidder or bulldozer).
- Less time to install and remove with an experienced operator.
- Minimal direct contact with the stream channel during installation and use.
- Less soil disturbance at the stream crossing site.
- No backfill material needed to be placed into the stream channel.
- Do not need to alter the stream channel or flow.
- Reusable for multiple years, making them economically competitive to culvert and ford options.
- Reduced cost and time needed for stabilizing the stream crossing after logging is completed.
- Easy to fabricate, or can be purchased prefabricated.
- Removal following the operation restricts unwanted traffic.
- Can be used to protect ditches at haul road access points (see figure 3).



Figure 3. NCFS bridgemats used in Edgecombe County, 2014 to protect a ditch from sedimentation.

Why Not Use Bridgemats Every time?

Some hindrances to using bridgemats include (in no order):

- Initial capital cost to purchase.
- Requires planning and equipment to handle, install, load and transport safely.
- Another piece of equipment for the logger to keep track of and maintain.
- May not always be suitable for heavy truck crossings or wide channel crossings.
- Not a permanent crossing option.
- Abutment installation may be necessary for weak bank conditions.
- May not be the most efficient and effective method for all site conditions.

Where Do I Find Bridgemats?

A list of known bridgemat and road mat manufacturers that supply North Carolina can be found on the NCFS webpage (http://ncforestservice.gov/water_quality/bridgemats.htm). This list is updated as new vendors are identified or as vendors request to be added or removed.

Where Do I Find Bridgemat Designs?



Constructing your own set of bridgemats may be a cheaper alternative if you have the necessary equipment and an appropriate design. Below are some pictures of different bridgemat designs observed by NCFS staff (Figures 4 and 5).



Figure 4: Six different steel bridgemat design configurations observed by NCFS staff.



Figure 5: One steel trailer with wooden travel surface and five different wood bridemat designs/configurations.

Below is a list of links that provide some design ideas. Note that if the bridge is to be used by the public the design should be done or approved by a qualified engineer. Since many loggers will not adopt a design that requires extensive time and labor to fabricate, the links below provide simplistic designs.

- University of Massachusetts Extension:
http://ncforestservice.gov/water_quality/pdf/UMass%20bridgemat%20Layout%20Sketch.pdf
- University of Kentucky:
http://dept.ca.uky.edu/masterlogger/pdfs/quizes/quiz_portablebridges73.pdf
- Vermont Agency of Natural Resources:
https://www.youtube.com/watch?time_continue=639&v=myEotaZGdEI
http://fpr.vermont.gov/forest/your_woods/harvesting_your_woodlots/skidder_bridge
- U.S. Forest Service
https://www.fpl.fs.fed.us/documnts/misc/em7700_8--entire-publication.pdf
- Taylor, S.E. and G.L. Murphy. 1992. Portable timber bridge designs for temporary forest roads. Presented at the Nashville Convention Center, 1992 International Winter Meeting. 1992 Dec. 15-18. Paper No. 924559. American Society of Agricultural Engineers, 2950 Niles Rd., St. Joesph, MI 49085-9659 USA.
https://www.ncforestservice.gov/water_quality/pdf/1992TaylorandMurphy_PortableBridgematDesign.pdf

NCFS Bridgemat Loan Service Delivery

Since the mid-1990s, the NCFS has provided bridgemats to loggers for establishing temporary crossings. Up until 2003, all bridgemats made available by the NCFS were those constructed of wood/timber beams, with panels ranging in lengths from 20-feet to 24-feet. All wooden bridgemats have been retired from this service. In 2003, the NCFS made its first purchase of fabricated steel bridgemats and began recording loan events. In 2005 and 2008, additional steel bridgemats were purchased, which made the service available in more areas of the state. As of December 2017, NCFS had 15 serviceable steel bridgemats enrolled in this service program. Purchase price, home base location and NCFS contact information for these bridgemats can be found in Appendix A.

Several dozen timber bridgemats were obtained from the N.C. Department of Transportation (NCDOT), after the mats were turned-in from a large highway construction project. Several sets of bridgemats were retrieved by NCFS Districts, to be loaned to loggers and for possible use as footbridges on State Forest lands (figure 6).



Figure 6: Old timber bridgemats donated by NCDOT, at the NCFS Fayetteville District Office. Photo taken January 2014.



Between 2009 and 2017, documented loans of NCFS owned bridgemats were used on 452 logging jobs to establish 542 stream or ditch crossings and provided access to over 22,500 acres of timberland. The total estimated harvest acreage of those tracts in which NCFS bridgemats were used exceeds 31,600 acres. Therefore, the bridgemats were used, on average, to access about 71 percent of the harvested acres. A summary of these bridgemat loan metrics is depicted by year in Figures 7, 8, and 9.

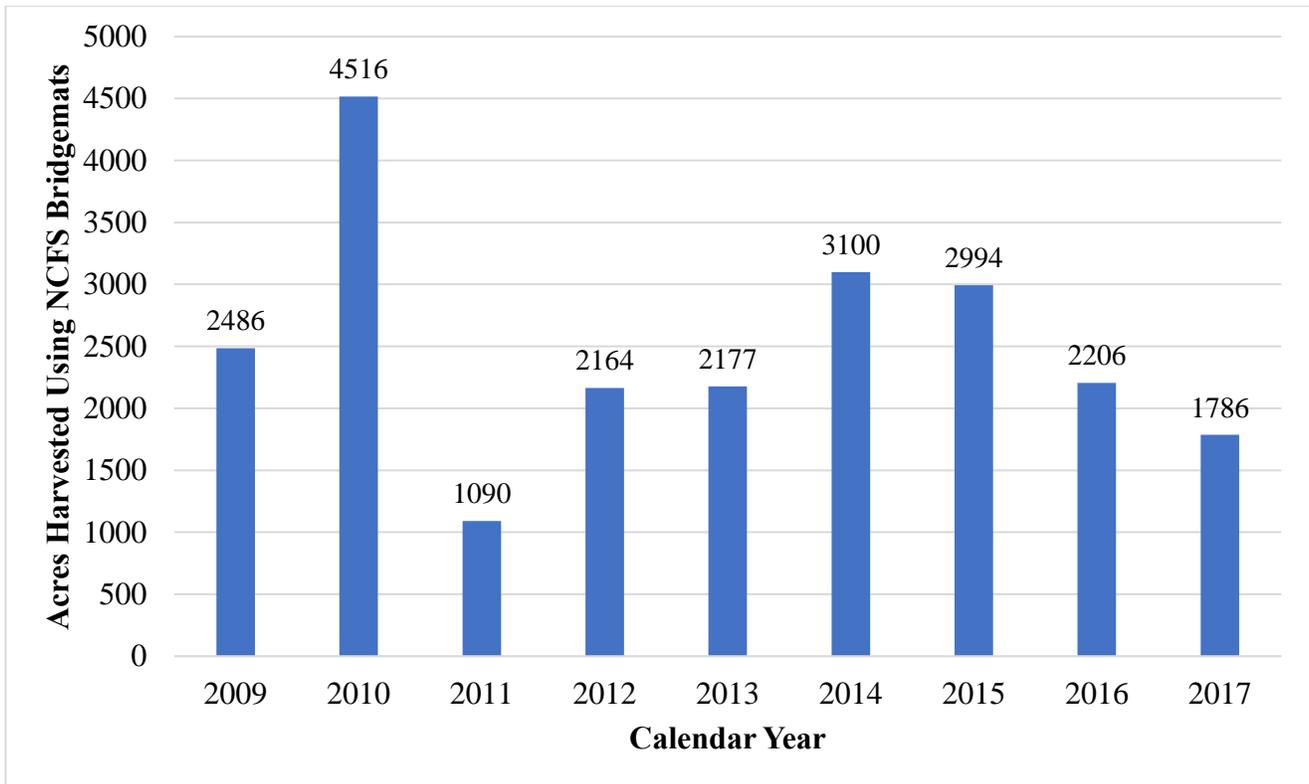


Figure 7: Number of acres harvested by using 16 sets of NCFS bridgemats summarized by year



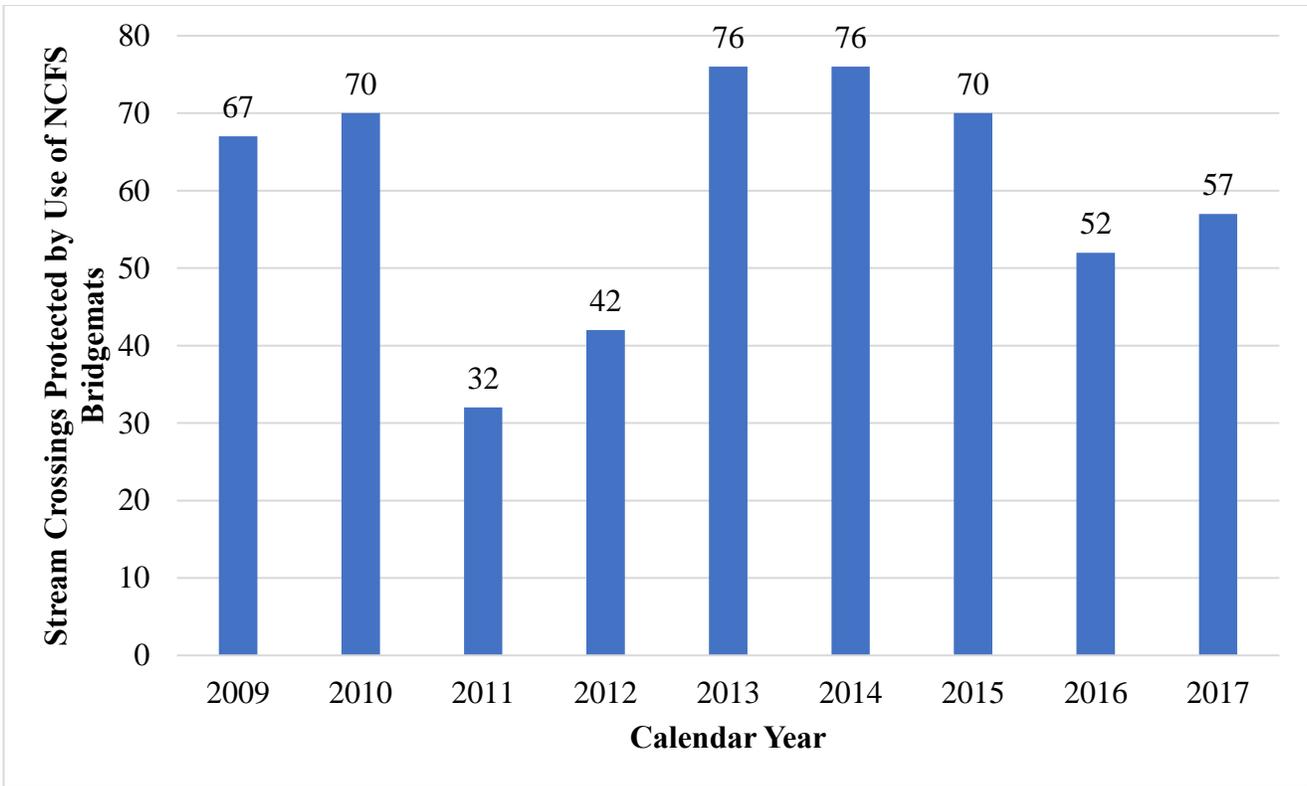


Figure 8: Number of stream crossings protected through use of 16 sets of NCFS bridgemats summarized by year.

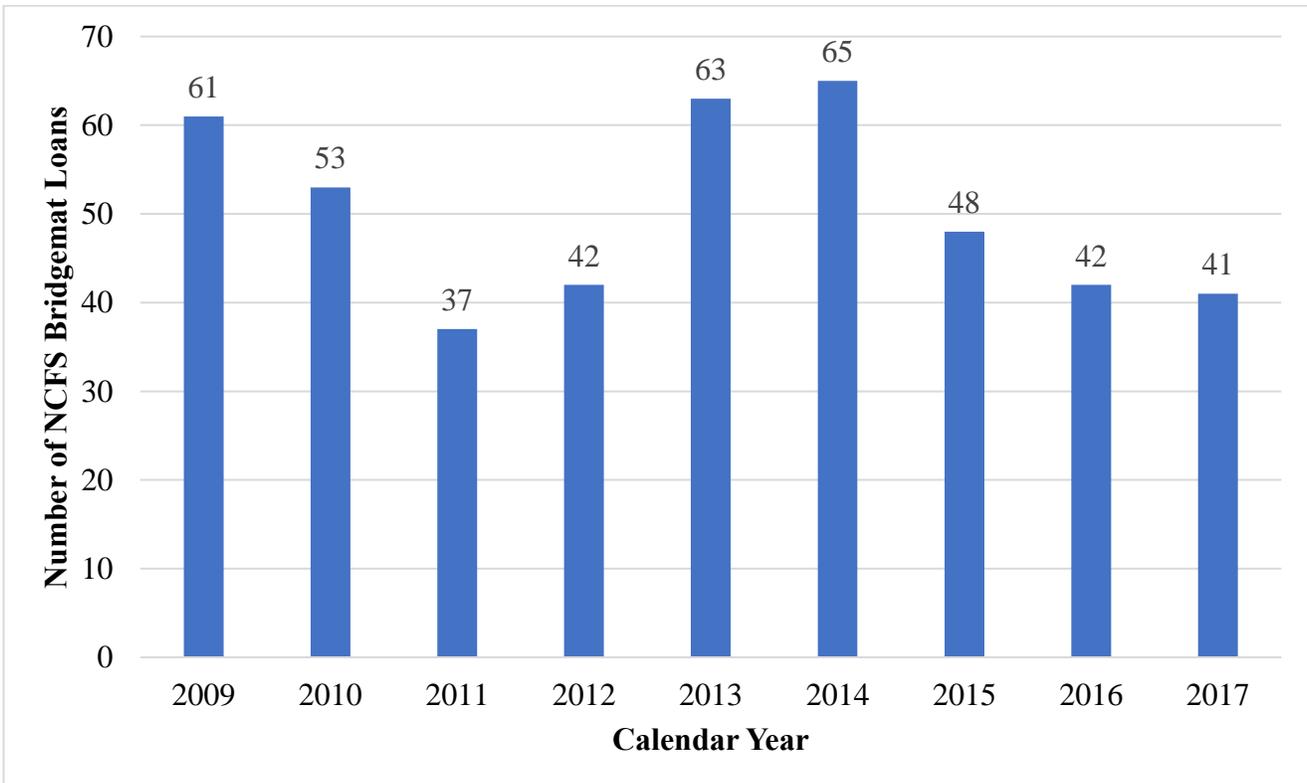


Figure 9: Number of recorded loaning events for all 16 sets of NCFS bridgemats summarized by year.



Loggers and timber buyers continue to access and support the NCFS bridgemat loan service. In some NCFS loaning districts, borrowers have utilized the service in a manner where they continually use NCFS bridgemats. The current directive in the service does not have a mechanism to discourage this action unless the bridgemats are requested by another customer. Based on direct customer communication and input by field staff, our customer base for this service has decreased since the 2002-2008 bridgemat status report. A decreasing customer base may be viewed as a program success as loggers have incorporated bridgemats into their normal operating practices. The 2012-2016 Best Management Practices Implementation Assessment results also support this viewpoint. In the assessment, the NCFS found that bridgemats were the most common stream crossing type encountered and had the fewest number water quality risks compared to culvert, ford and pole crossings (Coats 2018).

Tracking Bridgemat Usage

Consistently tracking the usage, location and general whereabouts of NCFS bridgemats is a cornerstone to reporting the success of the service. A one-page tracking form developed in 2002 was used by agency field staff to track the location and usage of the bridgemats. In 2016, the single tracking form was replaced by three forms to differentiate between the type of information collected based on the loan situation. These forms addressed field staff concerns over accountability, liability and communications between the NCFS and bridgemat borrowers. Reporting bridgemat metrics, shown in figures 7, 8 and 9, to the central office coordinator has been mandatory. However, the day-to-day management of the bridgemat service has been managed by the NCFS districts and counties with assistance provided by central office staff. This approach to tracking provides NCFS staff with the flexibility to manage the operational aspect of the service, while keeping record of bridgemat use. A brief description of each form is shown below. For more detail, see appendix B.

- **Sign out:** Maintained all basic information from the 2002 form but added language to define the liability agreement and accountabilities of the borrower. Borrowers initial six statement lines to acknowledge specified expectations.
- **Visited on Site:** Provided a separate record sheet for field staff so that the original form need not be carried into the field. This form provided more documentation space for site details and comments.
- **Returned or Moved:** This form provided field staff with some step-by-step questions to evaluate the condition of the returned bridgemats. A schematic of the panels is provided to indicate the approximate location of damage. This form also addressed concerns over documenting relocated bridgemats to a different logging site.

Tracking forms are kept up to date and maintained in a central filing system. Reminders are given to field staff responsible for relaying bridgemat use metrics. Making spot visits or site inspections when the bridgemats are being used allows field staff to keep tabs on how the bridgemats are holding up and provide technical assistance to the logger if needed. Documenting bridgemat use and condition through photographs also proves helpful.

The metrics associated with use of the bridgemats is recorded, and reported to multiple state and federal water-quality agencies. This type of information is valuable when a program is requested to show a tangible, measurable impact ‘on the ground’ of how much the bridgemats are being used, which can be extrapolated to estimate how their use contributes to nonpoint source pollution prevention and the implementation of forestry BMPs. While such information cannot estimate the *effectiveness* of bridgemats, the tracking mechanism can satisfactorily monitor and document the *implementation* of bridgemats.



Follow-up on the 2002-2008 Bridgemat Project Status Report

Two goals outlined in the previous (2009) bridgemat program status report have been accomplished. The first goal of measuring effectiveness was accomplished through completion of research with the USDA-Forest Service Southern Research Station. Published in 2017, Boggs and others sampled total suspended sediment (TSS) above and below five bridgemat and one culvert stream crossings preharvest, during-harvest and post-harvest. Each stream crossing had different site characteristics (i.e., differing approaches, soil types, land use history, watershed sizes, road class and closure BMPs). Slash was incorporated into the four temporary crossings, while all approaches were installed with customized water control structures (i.e., waterbars, turnouts, and/or broad-based dips). Post-harvest, all areas of bare soil near the stream received grass seed, lime fertilizer and straw. Comparisons between upstream and downstream TSS measures revealed that none of crossings had significantly increased TSS levels for any of the monitoring periods. Researchers concluded that customization of BMPs according to site conditions prevented increased risks for water quality impairment. Figure 10 depicts each of the stream crossings during the forest operations.



Figure 10. Stream crossing sites during forest operations as published in Boggs and others (2017). A) Wood bridgemats on temporary skid trail, B) Steel bridgemats on a temporary skid trail, C) Steel bridgemats on a temporary skid trail, D) Wood bridgemats on temporary skid trail, E) 30-inch diameter culvert on a permanent haul road, and F) Steel bridgemats on a permanent haul road.



The second goal outlined in the 2009 report was installing demonstration areas that showcase bridgemat stream crossings. In 2011, a set of three engineered-lumber Emtek™ bridgemats were installed over Purlear Creek at Rendezvous Mountain Educational State Forest in Wilkes County. The 3,500-pound bridgemats were fabricated of pressure-treated, and stress tested laminated lumber, then covered with a water-resistant coating to prolong their use. These bridgemats were then secured onto concrete abutments using steel end caps. Cross decking was then installed over the existing bridge to further strengthen and reinforce the structure. Another treatment of water-resistant coating and an additional metal ramp was applied. This stream crossings provides an example of a permanent bridgemat crossing that can be used for haul truck access. Figure 11 showcases pictures of the bridge installation process. The crossing provides the agency with vehicle access to an area of the State Forest that was previously isolated, due to the limitations of crossing the previously-restored reach of Purlear Creek. The use of 319-Grant funding to purchase and install this crossing demonstration complements the extensive capital investment of state funds that went into the overall restoration and protection of the Purlear Creek watershed on the State Forest.



Figure 11. A) Installation of treated **Emtek™** wooden bridgemat panels over Purlear Creek, B) Metal end-cap securing wooden panels to the concrete abutment, C) Cross decking installed atop the initial bridgemat paneling. D) Completed installation of the demonstration bridge.

Outreach and Education Efforts

Educational information was developed and produced for the Purlear Creek bridgemat crossing at Rendezvous Mountain Educational State Forest. The exhibit shows the before, during, and after photos of the crossing (figure 12).

Since 2011, the NCFS has conducted annual field lab exercises for college-level forestry students on BMPs and stream crossing selection. During these exercises, NCFS emphasized the use of bridgemats and reinforce the need for proper planning and communication. The NCFS has reached nearly 230 students in these classes, helping train the next generation of foresters on the benefits and practicalities of using bridgemats.



Figure 13. Wayne Community College (left) and North Carolina State University (right) students participating in the NCFS led stream crossing scenario exercise.

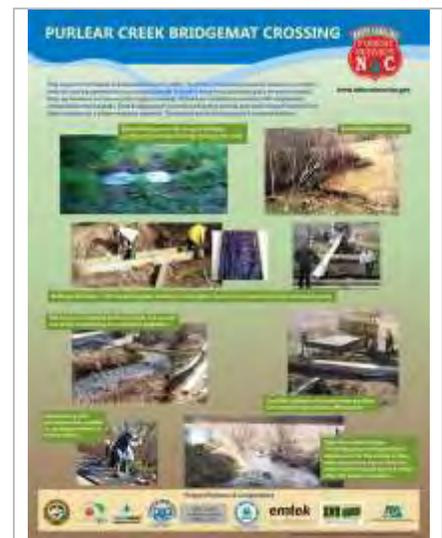


Figure 12. Project information depicting the construction stages of the Purlear creek bridgemat crossing at Rendezvous Mountain Educational State Forest.

Through 2017 and into 2018, the NCFS held eight Water Quality Refresher workshops across North Carolina, reaching about 300 forestry, water quality and natural resource professionals. A portion of each workshop was dedicated to an overview of different stream crossing options and applicable BMPs. Information from the presentation, “Fundamentals of Stream Crossings”, is on the NCFS website at (http://ncforestservice.gov/water_quality/wq_presentations/2017-NCFS-WQrefresher-3xings.pdf).



Figure 14. Attendees at two of the eight water quality refresher workshops in 2017.



Emergency Assistance Applications

Bridgemats are often used in construction work such as utility corridor clearings, building developments and agriculture, however, NCFS bridgemats are not intended for non-forestry use. An exception is made when requested to respond to emergency incidents, in cooperation with the county Emergency Management and/or local fire departments or law enforcement. These requests are infrequent, but typically come following large storm events that wash away public road culverts. Below are a few instances where NCFS assisted communities by using agency bridgemats (Figures 12, 13, and 14).



Figure 15: July 2013, NCFS Asheville District's bridgemats being installed for public road access after flooding in Madison County, NC. The bridgemats provided homeowners access to their homes until the crossing could be repaired.



Figure 16 (above two pictures): September 2016, NCFS Hillsborough District's bridgemats installed for public road access following Hurricane Matthew in Alamance County, NC. This temporary fix provided access to dozens of homes and was highlighted by local television media.



Figure 17 (left two pictures): November 2017, NCFS Asheville District's bridgemats were installed following severe storms caused damage to a low-water crossing in Buncombe County, NC. NCFS Bridgemats were placed about 30-ft upstream and served as the primary access to several homes until the crossing was repaired.



Applied Forestry Research at Stream Crossings

Since the previous status report, several applied research projects pertaining to stream crossings in regions similar to North Carolina's have been completed. These projects are summarized in a chronologically ordered annotated bibliography below. Citations of the sources are noted in the Reference section.

Aust and others (2011) monitored sediment from 23 Piedmont stream crossings before installation, during installation, as well as during and after harvest. The stream crossing types included bridgemats, culverts, reinforced fords, and culverts covered with pole-sized logs. They found that the least disruptive crossing type was bridge, but the characteristics of the stream crossing approaches and longevity of the crossing (temporary versus permanent) were more influential on water quality measures. They caution readers that crossing type should be selected based on individual site factors and that each crossing type can effectively protect water quality under certain site conditions.

McKee and others (2012) conducted a survey of 70 loggers across the Virginia Mountains, Piedmont and Coastal Plain regions to examine patterns of stream crossings and BMPs. Coastal Plain loggers primarily used bridgemats. Piedmont loggers used a combination of bridgemats and culverts. Mountain loggers mainly used culverts for stream crossings. Most loggers reported significant costs associated with closing/rehabilitating stream crossings post-harvest.

Wear and others (2013) examined three types of closure techniques for skid trail stream crossings on nine Piedmont streams. All crossings used temporary steel bridgemats and were closed by contractors. The treatments were: 1) Logging debris (slash), 2) mulch/straw and grass seed (mulch) and 3) mulch/straw, grass seed and silt fence (silt fence). Sediment was measured upstream and downstream of each crossing daily for one year. Slash and mulch treatments had the lowest sediment delivery, while silt fence resulted in a higher sediment level. The researchers suspected that the silt fence was installed too close to the stream and created a source of sediment. Researchers concluded that increased complexity and expenditures on BMPs cannot replace proper installation.

Brown and others (2013) compared five regraded bare soil legacy stream crossings approaches with four completely graveled stream crossing approaches and found that the average of the bare soil approaches produced 7.5 times more sediment than that of the graveled approaches. The highest sediment delivery rates were associated with high levels of bare soil and long approaches without water control structures.

Wang and others (2013) monitored sediment levels at the outlet of an 80-acre watershed in the Monongahela National Forest, West Virginia before, during and after 0.57-miles of haul road and three culvert stream crossings were constructed. Sediment delivery increased during construction then decrease post-construction, but remained elevated above pre-construction levels. The researchers noted a lack of adequate BMPs during the construction process and suggested that state BMP manuals need to better address specific techniques to control erosion during stream crossing construction.

Brown and others (2014) conducted rainfall simulations on six stream crossing approaches (three stream crossings) in the Piedmont. Low, intermediate and heavy rainfall rates were applied to bare soil surface, half-graveled approach (33 ft) and fully graveled approach (66 ft). They found that sediment yields from the bare soil surfaces were 2.6 times higher than the half-graveled approaches and 3.5 times higher than the fully graveled approaches. They concluded that reducing the length of the approach can reduce the costs associated with gravel needed. Furthermore, they demonstrated that low-cost BMPs can minimize sediment delivery from reopened legacy roads.



Morris and others (2016) improved the three stream crossings used in Brown et al. (2014) by installing a panel bridge, a culvert and a reinforced ford. They simulated three levels of rainfall (low, intermediate, heavy) over the crossings with three phases of BMP implementation that progressively reduced the amount of bare soil. Sediment yields were higher during the construction phases and during heavy rainfall simulation with low BMP implementation for all crossings. The culvert (with dirt backfill) consistently produced higher levels of sediment compared to the bridge and ford. Additional BMP enhancements were more critical for sediment control at the culvert and ford crossing than at the bridge.

Lang and others (2017) measured sediment delivery on 60 reconstructed haul road ditch segments (50-ft) near stream crossing the in the Mountain region of Virginia. Sediment delivery rates of four common ditch BMP applications (grass seed with lime fertilizer, grass seed with lime fertilizer and erosion control mat, rock check dams, and completely rocked) and a control (bare soil) were compared. Results suggested that erosion control mats had significantly lower sediment delivery amounts than bare soil and check dam treatments, while completely rocked and grass seed without erosion control mat provided intermediate levels. The authors also found that erosion began to accelerate disproportionately when bare soil levels were between 30 percent and 50 percent; therefore, 50 percent soil cover is recommended for ditches near streams.

Lang and others (2018) measured sediment delivery on 37 haul road stream crossing approaches representing a spectrum of road quality and BMPs in the Mountain and Piedmont regions of Virginia. Piedmont study sites produced more sediment than the Mountain sites. This finding was attributed to the better-quality/better road design in the Mountains. Stream crossing approaches with low BMP implementation levels produced the most sediment. Sediment delivery varied according to site specific conditions, but generally increased on approaches with bare soil exceeding 50 percent and failing water control structures. Authors recommended that managers carefully evaluate water contributing area of the stream crossing approach and apply BMPs that will slow and spread runoff before reaching the stream.

Conclusions

Land managers need to carefully evaluate proposed and existing road networks for forestry operations. Bridgemats are frequently an economically and environmentally viable option for temporary stream crossing situations for silvicultural purposes. Several researchers and practitioners have noted many advantages to bridgemats. However, it is recognized that each site is different and bridgemats may not always be a suitable option. In these cases, a crossing that meets water quality standards and landowner objectives should be chosen. Regardless of the crossing type, most of the potential sediment originates on the road approaches and should be stabilized using BMPs that are appropriate for the site characteristics. Developing a plan and involving local forestry experts will often reduce water quality risks and save money in the long run.

The NCFS Bridgemat and Education Loan Service has proven be an excellent outreach program. NCFS continues to provide this service, but also continually evaluates ways to improve and provide better services to our customers. Thank you for your continued support and feedback on this service.



References

- Aust, W.M., M.B. Carroll, M.C. Bolding, and C.A. Dolloff. 2011. Operational forest stream crossings effects on water quality in the Virginia Piedmont. *Southern Journal of Applied Forestry* 35(3): 123-130.
- Brown, K.R., K.J. McGuire, W.M. Aust, W.C. Hession, and C.A. Dolloff. 2014. The effect of increasing gravel cover on forest roads for reduced sediment delivery to stream crossings. *Hydrological Processes* 29(6):1129-1140.
- Brown, K.R., W.M. Aust, and K.J. McGuire. 2013. Sediment delivery from bare and graveled forest road stream crossing approaches in the Virginia Piedmont. *Forest Ecology and Management* 310: 836-846.
- Coats, W.A. 2017. "[An Assessment of Forestry Best Management Practices in North Carolina, 2012-2016.](#)" NCDA&CS-North Carolina Forest Service. Raleigh, N.C.
- Lang, A.J., W.M. Aust, M.C. Bolding, K.J. McGuire, E.B. Schilling. 2017. Forestry best management practices for erosion control in haul road ditches near stream crossings. *Journal of Soil and Water Conservation* 72(6): 607-618. doi: 10.2489/jswc.72.6.607.
- Lang, A.J., W.M. Aust, M.C. Bolding, K.J. McGuire, E.B. Schilling. 2018. Best management practices influence sediment delivery from road stream crossings to Mountain and Piedmont streams. *Forest Science* 1-14. doi: 10.1093/forsci/fxy019.
- McKee, S.E., L.A. Shenk, M.C. Bolding, and W.M. Aust. 2012. Stream crossing methods, cost, and best management practices for Virginia loggers. *Southern Journal of Applied Forestry* 36(1):33-37.
- Morris, B.C., M.C. Bolding, W.M. Aust, K.J. McGuire, E.B. Schilling, and J. Sullivan. 2016. Differing levels of forestry best management practices at stream crossing structures affect sediment delivery and installation costs. *Water*. 8(3): 92.
- Wang, J., P.J. Edwards, and F. Wood. 2013. Turbidity and suspended-sediment changes from stream-crossing construction on a forest haul road in West Virginia, USA. *International Journal of Forest Engineering* 24(1): 76-90.
- Wear, L.R., W.M. Aust, M.C. Bolding, B.D. Strahm, and C.A. Dolloff. 2013. Effectiveness of best management practices for sediment reduction at operational forest stream crossings. *Forest Ecology and Management* 289:551-561.

Appendix

Appendix A: NCFS's purchases of bridgemats, assigned bridgemat locations, and NCFS contact information for borrowers (sorted by district number).....	15
Appendix B: NCFS Bridgemat Tracking Forms.....	16
Appendix C: List of Known Bridgemat Suppliers.....	19



Appendix A: NCFS's purchases of bridgemats, assigned base of operation, and NCFS contact information for borrowers (sorted by district number).

Purchase Year	Cost*	Inventory Control Numbers (FAS)	Length (feet)	Assigned District	Office Number
2003	\$6,667	158766,767,768	25ft	Asheville (D1)	828-667-5211
2003	\$6,667	158775,776,777	25ft	Lenoir (D2)	828-757-5611
2005	\$12,755	164953,954,955	30ft	Lenoir (D2)	828-757-5611
2003	\$6,667	158772,773,774	25ft	Rockingham (D3)	910-997-9220
2008	\$12,918	178601,602,603	25ft	Rocky Mount (D5)	252-442-1626
2003	\$6,667	158769,770,771	25ft	Fayetteville (D6)	910-437-2620
2005	\$12,755	164959,960,961	30ft	Elizabeth City (D7)	252-331-4781
2005	\$12,755	164950,951,952	30ft	Elizabeth City (D7)	252-331-4781
2005	\$12,755	164947,948,949	30ft	Whiteville (D8)	910-642-5093
2005	\$12,755	164956,957,958	30ft	Whiteville (D8)	910-642-5093
2008	\$12,918	178589,596,597	25ft	Sylva (D9)	828-586-4007
2008	\$12,918	178589,590,595	25ft	Sylva (D9)	828-586-4007
2008	\$12,918	178592,593,594	25ft	Lexington (D10)	336-956-2111
2008	\$12,918	178598,599,600	25ft	Hillsborough (D11)	919-732-8105
2008	++	345, 346, 347	25ft	Hillsborough (D11)	919-732-8105

* Bulk prices paid for 21 panels in 2003 and 15 panels in 2005 and 2008. When used, bridgemats are allocated in 'sets' consisting of three individual bridgemat panels.

++ Funding acquired from local watershed grant and managed by district 11 office.

Note the substantial increase in price for steel bridgemats between 2003 and 2005 - this is due directly to the worldwide increase in steel prices.





*Complete every time bridgemats are **LOANED OUT***
N.C. Forest Service Bridgemat Tracking Form



SIGNOUT

Today's Date: _____ Customer's Name: _____
 FAS #'s: _____ Contact Email: _____
 District: _____ Contact Number: _____
 County: _____ Company: _____
 Job Site Location/Address: _____
 _____ (draw a map on the back if needed)

A refundable deposit of \$_____ will be required from the borrower, payable to the North Carolina Forest Service on or before the effective loan day.

<i>Acres of access gained by using NCFS bridgemats</i>	
<i>Acres of the total harvest area</i>	
<i>Number of crossings using NCFS bridgemats</i>	

I, the borrower, hereby declare as follows:

- 1.) That by participating in the N.C. Forest Service Bridgemat Loan Program I acknowledge my obligation to **return the loaned Bridgemat set on or before** _____ (date determined by N.C. Forest Service Personnel). I also understand that an extension may be requested in writing at least one week prior to the above date (_____). I understand that my **request may be approved or disapproved** by N.C. Forest Service. I may send an extension request to _____ **Initials** _____
- 2.) That I understand that there is no charge to borrow the bridgemat set. **However**, if damaged beyond normal wear, lost, or stolen while the bridgemats are loaned to me, I acknowledge that **I will be held accountable for the repair or replacement of the loaned bridgemats**. This will require me to repair/replace bridgemats to the condition in which they were loaned to me or of better quality. If I do not repair or replace damaged or lost/stolen bridgemats within 30 days after my rental period, I authorize the N.C. Forest Service to use my deposit at their discretion and I will provide additional funds as necessary to recover the cost of time and equipment incurred by the State as it pertains to the loaned bridgemats repair/replacement. **Initials** _____
- 3.) That I release from liability and agree to indemnify and hold harmless N.C. Forest Service, and any of its staff, for any liability in connection with the use or possession of the bridgemats. This release is for any and all liability for personal injuries (including death) and property losses or damage caused by, or in connection with the possession or use of the equipment. This includes but is not limited to loading/unloading, securing, transporting, and/or placement. **Initials** _____
- 4.) That I understand that the State of North Carolina and the N.C. Forest Service make no assurances or guarantees as to the integrity or the soundness of the bridgemat set. I will use the bridgemats at my own risk. **Initials** _____
- 5.) That I will use the bridgemat set for their intended purpose (to cross streams and ditches). For other uses, I will request in writing and wait for written approval by N.C. Forest Service personnel before using the bridgemats for any other purpose. **Initials** _____
- 6.) That I agree to allow N.C. Forest Service personnel to inspect the bridgemat set **at any time** and I understand that a **\$100** fee may be issued if the bridgemats are not located at the specified location on this form. **Relocation of the bridgemats without written permission is strictly prohibited.** **Initials** _____

Applicant's Signature _____ Date _____
 N.C. Forest Service _____ Date _____



Complete every time bridgemats are VISITED ON SITE
N.C. Forest Service Bridgemat Inspection Form



Inspection Date: _____

Inspector's Name: _____

FAS #'s: _____

District: _____

Inspection Site (lat/long or address): _____

County: _____

In-use Inspection Questions

Circle one

Are there gaps less than 12 inches between panels?_

Yes No NA

Were bumper trees utilized?

Yes No NA

Are approaches stable and unlikely to contribute sediment?

Yes No NA

Is concentrated runoff captured or diverted away from streams?

Yes No NA

In your opinion, was this the best location to cross?

Yes No NA

In your opinion, were bridgemats the best method of crossing?

Yes No NA

At how many crossings were NCFS bridgemats actually used?

1 2 3 _____

NCFS bridgemats were used to cross a(n):

Ditch Ephemeral Intermittent Perennial Other

If removed, are water and stream/channel minimally disturbed?

Yes No NA

What BMPs have been implemented at the crossing(s) and along the approach ways? _____

What recommendations/comments do you have for the logger, regarding the bridgemat crossing(s)? _____

Explain any issues/concerns or other comments: _____

Insert Applicable Bridge Mat Photos Depicting Customer Use or Showing Damage as Illustrated Below



Appendix C: List of Known Bridgemat Suppliers

Suppliers of Bridgemats, Portable Bridges, Dragline Mats and Logging Mats

This is not intended to be a complete list of suppliers. This information has been prepared to assist those who may require this equipment for forestry operations. Potential buyers should compare costs and specifications before ordering a mat to ensure that the equipment fits the job needs. Inclusion on this list does not imply recommendation nor any guarantee by the State of North Carolina related to the purchase or use of these products. Not all vendors listed here offer all types of mats. You should contact each vendor to determine what products they have available for your intended use.

Steel Bridgemats (portable logging bridges)

Atlas Welding	corey@atlaswelding.us	(336) 395-3740	1215 Gant Road	Graham, NC 27253
DAMCO, Inc.	damco @ earthlink.com	(252) 633-1404	P.O. Box 1656	New Bern, NC 28563
Hitch Crafters	www.hitchcrafter.com	(336) 859-3257	853 Cid Road	Lexington, NC 27292
KM Machine Company	www.kmmachineco.com	1/877-428-2368	275 Sedberry Road	Biscoe, NC 27209
Production Welding & Fabrication		(828) 687-7466	1791 Brevard Road	Arden, NC 28704
T&W Machine and Welding		(919) 934-6077	1896 Mallard Road	Smithfield, NC 27577
Wharam Welding and Repair Service		(434) 983-3933	273 Allens Lake Road	Dillwyn, VA 23936

Wood, Timber, Engineered Lumber, or Composite Mats (for bridges or roads)

Advantage Lumber Company:	advantagelumber @ yahoo.com	1/877-612-3656	926 Anthony Avenue	Opelousas, LA 70570
Arcola Lumber Company:		(252) 257-1139	2316 Highway 43	Warrenton, NC 27589
Anthony Hardwood Composites:	http://anthonycomposites.com/	(870) 942-4000	PO Box 490	Sheridan, AR 72150-0490
Bridgewell Resources LLC:	www.bridgewellresources.com	1/800-570-3566	10200 SW Greenburg Rd, Suite 500	Tigard, OR 97281
Carolina Mat Inc.:	www.carolinamat.com	(252) 793-4045	193 Hwy149-North	Plymouth, NC 27962
Custom Cut Timber Products:		(478) 994-0167	701 W. Main St	Forsyth, GA 31029
Dixie Mat:	www.dixiemat.com	1/800-927-2059	236 Herring Road	Sandy Hook, MS 39478
Garnett Wood Products:	www.garnettwood.com	1/888-427-6388	P.O. Box 525	Brandsville, MO 65688
Hopewell Hardwood Sales:	hopewellhardwoods@earthlink.net	(804) 458-5178	5333 Hall Farm Rd	Prince George, VA 23875
Long Lumber Company:		(334) 886-3326	771 W.Bateman Ave	Slocomb, AL 36375
Mabey, Inc.	www.mabey.com	866-557-4102	6770 Dorsey Road	Elkridge, MD 21075
Richard West Co., Inc.:	www.richardwestcompany.com	(252) 793-4440	174 US Hwy64-West	Plymouth, NC 27962
Sound Industries:	www.oakmats.com	(208) 777-9025	1810 Schneidmiller Ave, Suite 340	Post Falls, ID 83854
South Eastern Timber Corp:	www.crane-mats.com	(954) 752-3800	PO Box 9289	Coral Springs, FL 33075
Sterling Lumber Company:	www.sterlinglumber.com	(708) 388-2223	3415 West 127th St	Blue Island, IL 60406
SVE Portable Roadway Systems, Inc.	www.mudtraks.com	(239) 560-2259	6128-F Brookshire Blvd.	Charlotte, NC 28216
T. E. Johnson Lumber Co.		(919) 963-2233	3872 Old School Rd	Four Oaks, NC 27524
The Mat Source:	www.thematsource.com	1/877-867-6287		
Tumac Lumber Co:	http://tumac.com	1/800-925-7993	805 SW Broadway Suite 1500	Portland, OR 97205-3357
Twin Mills Timber & Tie:		(618) 932-3662	P.O. Box 34	West Frankfort, IL 62896





All photographs on the front and rear covers were taken in North Carolina by personnel of the N.C. Forest Service.

The North Carolina Forest Service is an equal opportunity / affirmative action employer. Its programs, activities and employment practices are available to all people regardless of race, color, religion, sex, age, national origin, handicap or political affiliation.

