Fish Passage Status of Road-Stream Crossings on Selected National Forests in the Southern Region, 2006

United States Department of Agriculture Forest Service
Southern Research Station
Center for Aquatic Technology Transfer
1650 Ramble Rd.
Blacksburg, VA 24060-6349

C. Andrew Dolloff, Team Leader

Report prepared by:
Seth Coffman, Megan Minter, and Craig Roghair

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Background

The ability to move freely through stream networks is an important aspect of a fish species' long-term viability (Fausch et al. 2002). Fish movement in streams prevents population fragmentation (Winston et al. 1991), allows for population recovery following disturbance (Detenbeck et al. 1992; Adams and Warren 2005; Roghair and Dolloff 2005), and provides access to critical habitats (Fausch and Young 1995). Early work examining effects of road-stream crossings on fish movement occurred primarily in the western U.S. and focused on anadromous Pacific salmon stocks. Effects of road-stream crossings on stream-resident fishes in the eastern U.S. received less attention, in part because such fishes were regarded as sedentary (Gerking 1959). Recent re-examination of historic movement studies (Gowan et al. 1994) and new research on a wide range of stream-resident fish species (Warren and Pardew 1998; Albanese et al. 2003; Schmetterling and Adams 2004) has shown a frequency and magnitude of movement that must be considered when making stream management decisions.

There are estimated to be over 50,000 road-stream crossings on National Forest managed lands in the eastern U.S. (M. Hudy, Forest Service U.S. Department of Agriculture, unpublished data). Each of these crossings represents a potential impediment or barrier to fish movement among stream reaches and watersheds. The Forest Service recognizes the importance of modifying or removing those crossings identified as barriers to meet its objective of restoring and maintaining native species diversity (Forest Service, U.S. Department of Agriculture 2004). In alignment with the Forest Service National Strategic Plan, the Southern Region has also listed the removal of barriers to fish and other aquatic organisms as a key strategy for meeting its critical objective of improving watershed condition (Southern Region Forest Service, U.S. Department of Agriculture *Draft*).

In 2003 and 2004 the U.S. Forest Service Southern and Eastern Regions and the San Dimas Technology and Development Center (SDTDC) hosted several fish passage assessment and remediation workshops. The National Inventory and Assessment Procedure (NIAP) (Clarkin et al. 2003) presented at these workshops provided a framework for collecting field data, but the assessment models, designed for western U.S. fish species, were not directly applicable to most species in the eastern U.S. The southeastern U.S. has over 660 freshwater fish species in 27 families encompassing a wide range of swimming and leaping abilities (Warren et al. 2000). Development of species-specific passage models was considered impractical and lack of data on leaping and swimming ability for most eastern fish species limited the usefulness of previously developed passage assessment software such as FishXing (Love et al. 1999).

In 2003, graduate students and biologists of the U.S. Forest Service Aquatic Ecology Unit – East at James Madison University began to develop models that would allow managers to quickly assess the passage status of a crossing. Three 'coarse screening filters' were developed based on leaping and

swimming abilities: Filter A strong abilities; Filter B moderate abilities; and Filter C weak abilities. Model validation showed that when using data collected with the NAIP the coarse filters were reliable tools for predicting fish passage (Coffman 2005).

In 2005 the USFS Southern Region, pursuing its critical priority of improving watershed condition, elected to allocate 10% of its Roads and Trails (TRTR) funds annually for four years to inventory road-stream crossings and identify fish passage barriers in the Southern Region. To insure a quality product with consistent data collection and analysis the Region partnered with the Southern Research Station, Center for Aquatic Technology Transfer (CATT) to design and execute an inventory and assessment program for road-stream crossings. The CATT developed an inventory protocol based on the NIAP, deployed field crews to collect data, and then classified each crossing as passable, impassable or indeterminate for each of the three coarse filters described above. The CATT completed inventories on several Forests in summer 2005 (Coffman et al. 2005) and on the Apalachicola National Forest in January 2006 (Coffman et al. 2007). Between April and October 2006, surveys were conducted on the George Washington-Jefferson National Forest, Cherokee National Forest, National Forests in Alabama, Francis Marion-Sumter National Forest, National Forests in Mississippi, and National Forests in Texas (Figure 1). This report summarizes the results of road-stream crossing inventories performed by the CATT between April and October 2006.

Methods

Site Selection

In early March 2006, the Regional office reviewed work requests, selected Forests for site visits, and forwarded their selections to the CATT. The CATT contacted selected Forests in mid-March to request lists of road-stream crossings for survey. Forests selected crossings for survey non-randomly based on Forest-specific priorities.

Data Collection

Dimensions, characteristics, shape (Figure 2), and condition of road-stream crossing structures and data pertaining to the adjacent stream channel were recorded for each site following the National Inventory and Assessment Procedure (NIAP) for road-stream crossings (Clarkin et al. 2003). A CST/berger SAL series automatic level with 32x magnification mounted on a tripod and a 25-foot stadia rod graduated in tenths of feet were used to measure the elevation of the crossing structure inlet and outlet, tailwater control, and the water surface (Figure 3). A measuring tape marked in hundredths of a foot was used to measure the distance between the crossing inlet and outlet. Bankfull channel width was measured at three locations upstream of the crossing and three downstream where natural channel

geometry was intact (i.e. outside of the influence of the crossing structure). Photographs of the inlet and outlet were taken and each site was sketched on paper. Condition of the crossing structure was recorded and any natural barriers (e.g. waterfalls) immediately upstream or downstream were documented. Natural stream substrate covering the bottom of the crossing structure was recorded as continuous throughout the structure, discontinuous, or not present. Substrate had to cover 100% of the structure bottom for a crossing to receive a continuous throughout the structure designation.

Data Analysis

The elevation and distance measurements for the crossing inlet, crossing outlet, tailwater control, and water surface were used to calculate residual inlet depth, outlet drop, outlet perch, slope, and slope x length values for each crossing (Figure 3).

Residual inlet depth is calculated as

$$P_3 - P_1,$$

where P_3 is the tailwater control elevation of the outlet pool and P_1 is the crossing inlet elevation. Residual inlet depth values greater than zero indicate the structure is completely backwatered, allowing fish passage.

Outlet drop is calculated as

$$P_2 - P_3,$$

where P_2 is the crossing outlet elevation and P_3 is the tailwater control elevation of the outlet pool.

Outlet perch is calculated as

$$P_2 - Ws,$$

where P_2 is the crossing outlet elevation and Ws is the water surface elevation immediately downstream of the outlet. Outlet perch is used in place of outlet drop when a tailwater control is not present and outlet drop cannot be calculated. Excessive outlet drop or outlet perch values indicate the presence of jump barriers.

Slope is calculated as

$$(P_{1elev} - P_{2elev}) / (P_{1dist} - P_{2dist}) * 100,$$

where P_{1elev} is the crossing inlet elevation, P_{2elev} is the crossing outlet elevation, P_{1dist} is the crossing inlet distance, and P_{2dist} is the crossing outlet distance. Steep slope is an indicator of velocity barriers.

Slope x length is calculated as

$$[(P_{1elev} - P_{2elev}) / (P_{1dist} - P_{2dist}) * 100] * (P_{1dist} - P_{2dist}),$$

where P_{1elev} is the crossing inlet elevation, P_{2elev} is the crossing outlet elevation, P_{1dist} is the crossing inlet distance, and P_{2dist} is the crossing outlet distance. High slope x length values indicate an exhaustion barrier.

Percent of crossing structure bottom with natural substrate, residual inlet depth, outlet drop, outlet perch, slope, and slope x length values for each crossing were applied to each of three regional coarse filters (Figures 4 – 6) to determine upstream passage status. Threshold values for each parameter differ by filter and were set according to published swimming and leaping abilities of representative species in each filter group, and relationships among crossing dimensions, species presence/absence data, and movement data (Coffman 2005). Filter A (Figure 4) classifies crossings for species with strong swimming and leaping abilities, such as the adult brook trout (*Salvelinus fontinalis*). Filter B (Figure 5) classifies crossings for species with moderate swimming and leaping abilities such as juvenile trout or species in the minnow family (Cyprinidae). Filter C (Figure 6) classifies crossings for weak swimmers and leapers, such as species in the darter (Percidae) and sculpin (Cottidae) families. Crossings are classified as passable, impassable, or indeterminate for each of the three filters. Biological sampling or computer modeling is required to determine passage status for crossings classified as indeterminate.

The ratio of culvert width to bankfull channel width was also calculated for each site. The ratio is calculated as

$$CW / BCW,$$

where CW is the maximum width or diameter of the crossing structure and BCW is the average of all six (three upstream and three downstream) bankfull channel width measurements. A ratio of 1.0 or greater indicates that the crossing structure is equal to or greater than the width of the bankfull channel. Fords, vented fords, and sites with multiple crossing structures were eliminated from this analysis.

Special Cases

Sites with more than one crossing structure (e.g. culverted site with multiple pipes) were occasionally encountered during the surveys. At these sites each individual structure was numbered sequentially from left to right when facing downstream. Each individual structure was then surveyed and classified, which could result in a single site having multiple classifications for a given filter. Under those circumstances the location was classified based on the structure that received the best passage rating. For example, in a crossing location with two circular culverts where one was classified as impassable and one indeterminate by Filter B, the location would receive an overall classification of indeterminate rather than impassable.

By definition open bottom arches receive a natural substrate continuous throughout structure designation, thus these structures receive a passable classification by default for each coarse filter. Full surveys were still completed at open bottom arches to capture channel conditions and crossing structure dimensions.

Crossing location was documented but the structure was not surveyed if there was inadequate habitat upstream of the crossing to support fish, or if the crossing structure was a bridge or natural ford. Bridges and natural fords were assumed to always provide adequate upstream fish passage. Crossing locations that could not be reached because of inaccessible or closed roads, private property issues, or locked gates were also documented, but not surveyed.

Results

We completed surveys at 431 of 633 documented road-stream crossings in 2006 (Table 1). The majority of all crossings were either impassable or indeterminate for all filters. Only 47%, 30%, and 24% of these crossings were rated passable by Filters A, B, and C respectively (Figures 7-9, Table 2). The percentage of crossings rated impassable, passable, and indeterminate by each Filter varied among Forests surveyed in 2006 (Figures 10-12). Excessive outlet drops accounted for 69%, 82%, and 91% of the impassable sites for Filters A, B, and C respectively (Table 3).

The majority of crossings surveyed were either circular culvert (61%, n=265) or pipe arches (20%, n=87). Box culverts (11%, n=49), vented fords (4%, n=16), concrete slab fords (1%, n=4), and bottomless arches (3%, n=10) were less frequently encountered. Filter A classified 11% of circular culverts and 13% of pipe arch crossings as impassable (Figure 13, Table 4). The proportion of circular culverts and pipe arches classified impassable increased from Filter A to Filters B and C. Filter B classified 40% of circular culverts and 57% of pipe arch crossings as impassable (Figure 14, Table 4). Filter C classified 53% of circular culverts and 67% of pipe arches as impassable (Figure 15, Table 4).

Crossing width was less than the bankfull channel width at more than 80% of all surveyed crossings (excluding fords, vented fords, and multiple structure crossings). The crossing width to channel width ratio was 0.73 ± 0.35 (mean ± SD) (n=267) (Figure 16). Only 51 crossings were greater than or equal to the mean bankfull channel width (i.e. crossing width to channel width ratio was greater than or equal to 1.0). The mean crossing width to channel width ratio for crossings classified impassable was significantly less than the mean ratio for crossings classified passable for all three filters (Table 5).

Discussion

Regional Analysis

Crossings that prevent upstream fish passage are a common feature of stream networks on southern Forests: less than 39% of the crossings surveyed on each Forest were rated as passable for all three filters. Outlet drop triggered passage failure at the majority of impassable sites, but it was not the only factor that would have prevented movement. Over 57% of sites classified as impassable due to excessive outlet drop by Filter C would also have failed due to either excessive slope or slope x length

values. Even if fish had managed to find a way to leap into these crossing structures they likely would have faced water velocities that exceeded their swimming abilities or a combination of water velocity and pipe length that would have exhausted them before they could exit the upstream end of the structure. These conditions are created when crossing structures do not mimic natural channel characteristics such as bankfull channel width, slope, and substrate. Impassable crossing structures typically concentrate water into a steeper, narrower channel profile with less resistance to flow. The result is increased water velocity within the structure and scouring immediately downstream creating an outlet drop, or perch (Castro 2003). This effect is exaggerated in high gradient streams which may explain why the George Washington-Jefferson NF and Cherokee NF, which had the highest gradient streams for Forests inventoried in 2006, also had the highest proportion of sites that failed for all three filters. Streams in the other Forests were primarily low gradient where failure for Filter A suggests extreme passage problems.

The vast majority of crossings structures surveyed were narrower than the natural bankfull channel. Undersized crossing structures disrupt natural stream processes such as transport of sediment and large woody debris, leading to blocked inlets or blowouts during storm events. Changes in stream flow and water velocities caused by undersized structures can lead to the development of passage barriers as discussed previously. The average width ratio of impassable sites was much less than the average width ratio of passable sites, however some sites with low width ratios were still classified as passable, which precludes this metric from being a reliable indicator of passage status. One possible explanation for this could be varying ages of crossing structures. Initial installation of undersized culverts may not immediately result in passage barriers, but over time the combined effect of varying flows and the unnatural characteristics/dimensions of the crossings can lead to the creation of barriers. The width ratio is unlikely to change dramatically over time, but the filter classification could due to events such as downstream scour and uneven settling of culverts.

The high proportion of impassable crossings for Filters B and C is particularly troubling. Minnow and darter species, many of which are represented by Filters B and C, constitute roughly 66% of the freshwater fish diversity in the Southeast and the majority of the 28% that are threatened, endangered, or vulnerable to extinction (Warren et al. 2000). Our results suggest that these moderate and weak swimming species face barriers to movement at 50-65% of the crossings we surveyed. The habitat fragmentation associated with these crossings likely contributes to continued species imperilment, and adds to the challenge of restoring connectivity.

All crossing types blocked upstream fish passage to some degree with the exception of open bottom arches, which are classified passable by default as discussed in the 'Special Cases' section of this report. Our survey results revealed that most open bottom arches had high crossing to channel width ratios (70% were greater than 1.0) creating residual inlet depth, outlet drop, and slope conditions similar

to the natural stream channel and thus favorable to fish passage. However, open bottom arches can be expensive and installation complicated compared to other crossing types (Murphy and Pyles 1989), which may explain why we encountered relatively few of these structures. Other than open bottom arches, box culverts and vented fords had the smallest percentage of impassable sites, but sample size for these types was low in 2006. Pipe arches and circular culverts were the most frequently encountered crossing type. Pipe arches and circular culverts dominate the road-stream crossing landscape because they are the most readily available and cost effective to install, but as our results demonstrate, they can create passage problems when stream hydrology and biological factors are not carefully considered prior to installation (Baker and Votapka 1990).

Current Limitations and Future Improvements

The coarse filters presented here apply to several general categories of fish including strong swimmers and leapers (Filter A), moderate swimmers and leapers (Filter B), and weak swimmers and leapers (Filter C). We assigned adult trout to represent Filter A, minnows and young trout to represent Filter B, and darters and sculpins to represent Filter C, however there are a range of swimming and leaping abilities represented within each family. For example some minnow species are strong swimmers and therefore may be most appropriately assessed by Filter A, whereas other weak swimming minnows may be candidates for Filter C. Still other families or species, such as those that are strong swimmers but weak to moderate leapers may require the creation of additional filters. Currently, few data are available regarding swimming and leaping abilities of non-game fish species in the Southeast making it difficult to refine or expand the existing set of filters. Members of the sucker (Catostomidae), catfish (Ictuluridae) and sunfish (Centrarchidae) families may fit into such filters, but clearly more research is needed.

Results provided by the existing filters include a sometimes large area of indeterminate passage status. Crossings enter this “gray area” when they pass for outlet drop and slope but do not pass or fail for slope x length. The range of values that leads to an indeterminate classification for slope x length can be quite large, particularly for Filter A leaving a large portion of sites essentially unclassified. The slope x length value represents the relative level of exhaustion a fish would experience by trying to swim through a pipe of a certain slope for a given distance. Because few empirical data exist for species exhaustion rates the filters were designed to be conservative. Biological sampling can provide important information for evaluating fish passage at sites classified indeterminate and generally with little expense relative to the cost of replacing a crossing structure. Mark-recapture sampling designs can vary in complexity and effort depending on project goals (Warren and Pardew 1998) and provide direct evidence of fish passage without the assumptions of fish passage models. The mark recapture design can be as simple as marking and releasing a sample of fish downstream of a crossing, and then sampling for marked fish above the crossing on subsequent sampling trips. Collection of marked fish above the crossing would

indicate that crossing is passable for the species in question. More elaborate designs to detect if movement through the crossing is the same or similar to movement through the unobstructed natural stream channel can also be implemented (Coffman 2005). The use of mark-recapture studies at indeterminate sites would not only allow Forests to classify these sites as passable or impassable, but would also provide data necessary to refine the filter thresholds and shrink the gray areas.

The Forests have opportunities to improve fish passage at road-stream crossings both during routine maintenance, when crossing structures reach the end of their serviceable life, and when funding becomes available to replace crossings outside of the regular maintenance schedule. Managers should always consult with their biologists and hydrologists to determine whether routine replacements should include aquatic organism passage considerations. Selection of sites for replacement outside of the routine maintenance schedule can be more challenging. Currently, Forests can use the information from our surveys to locate impassable crossings that are candidates for replacement; however the number of impassable crossings per Forest makes selecting sites an overwhelming task. Survey results only provide passage status and exclude many other factors that should be considered when prioritizing crossings for replacement. Information such as miles of habitat upstream of a crossing, proximity to other barriers, cost of replacement, species presence, and species status (i.e. threatened, endangered, exotic invasive) need to be included in the decision process. Given the large number of impassable sites, using criteria such as these to prioritize sites for remediation can be time consuming and overwhelming.

Last year CATT proposed the development of a decision support system (DSS) to assist managers in prioritization of crossing remediation projects (Coffman et al. 2005). The DSS would allow managers to (1) prioritize watersheds for assessment based on selected watershed characteristics; and (2) after assessments are complete prioritize impassable crossings for replacement based on factors such as quantity and quality of habitat (Coffman et al. 2005). The CATT estimates that a working prototype DSS could be developed for one-tenth the expense of replacing a single culverted crossing (based on the installation of a 12 foot open bottom arch, 80 feet long with a 20 foot high road embankment that allows fish passage costs roughly $108,000 (USDA Forest Service 2006)). The DSS would help to ensure replacement crossing installations result in the most cost-effective benefit for the resource. A fully operational DSS would be a powerful tool for selecting from the large number of impassable crossings within each Forest.

In summer 2005, field crew efficiency was a major issue. Crews often arrived at Forests on short notice with little pre-visit reconnaissance or prioritization available for their use. As a result we surveyed only 22% of the sites we documented in 2005 (Coffman et al. 2005). Crew efficiency was greatly improved in 2006 (68% of sites documented were surveyed) due to increased coordination between the Region, Forests, and the CATT. The Region selected Forests early in the year allowing Forest staffs

sufficient time to prioritize crossings and focus the survey efforts. Crew efficiency is critical given the limited amount of time available to survey each Forest. Further improvements in efficiency can be made as Forest Service staffs continue to prioritize watersheds and identify critical aquatic habitats containing road-stream crossings.

The results of culvert inventories performed in the Southern Region in summer 2006 demonstrate the effects of road-stream crossings on aquatic organism passage in southern streams. Future inventories in the Region will expand the baseline data necessary to meet national and regional strategic goals, prioritize crossings for replacements, and compete for remediation funds.

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Acknowledgements

We would like to thank the CATT culvert field crew for collecting all of the data presented in this report. The field crew included Jonathan Daugherty, Rachel Studebaker, Chris Parkins, Jacob Elstein, Megan Minter, Colin Krause, Josh Badder, Kristy Sabo, and Lisa Kurian. We would also like to thank Shon Owens of the USDA NRCS for providing draft 6th level HUCs for National Forests in Texas, and Alan Clingenpeel for providing draft 6th level HUCs for the Homochitto and Holly Springs National Forests. In addition, we thank Leigh McDougal, Jim Kozik, and the Southern Region for providing assistance and funding for the surveys, along with Jeanne Riley, Dawn Kirk, John Moran, Dave Peterson, Jim Herrig, Marcia Carter, April Hargis, Sandie Kilpatrick, and Stephanie Steele for their assistance with field logistics.

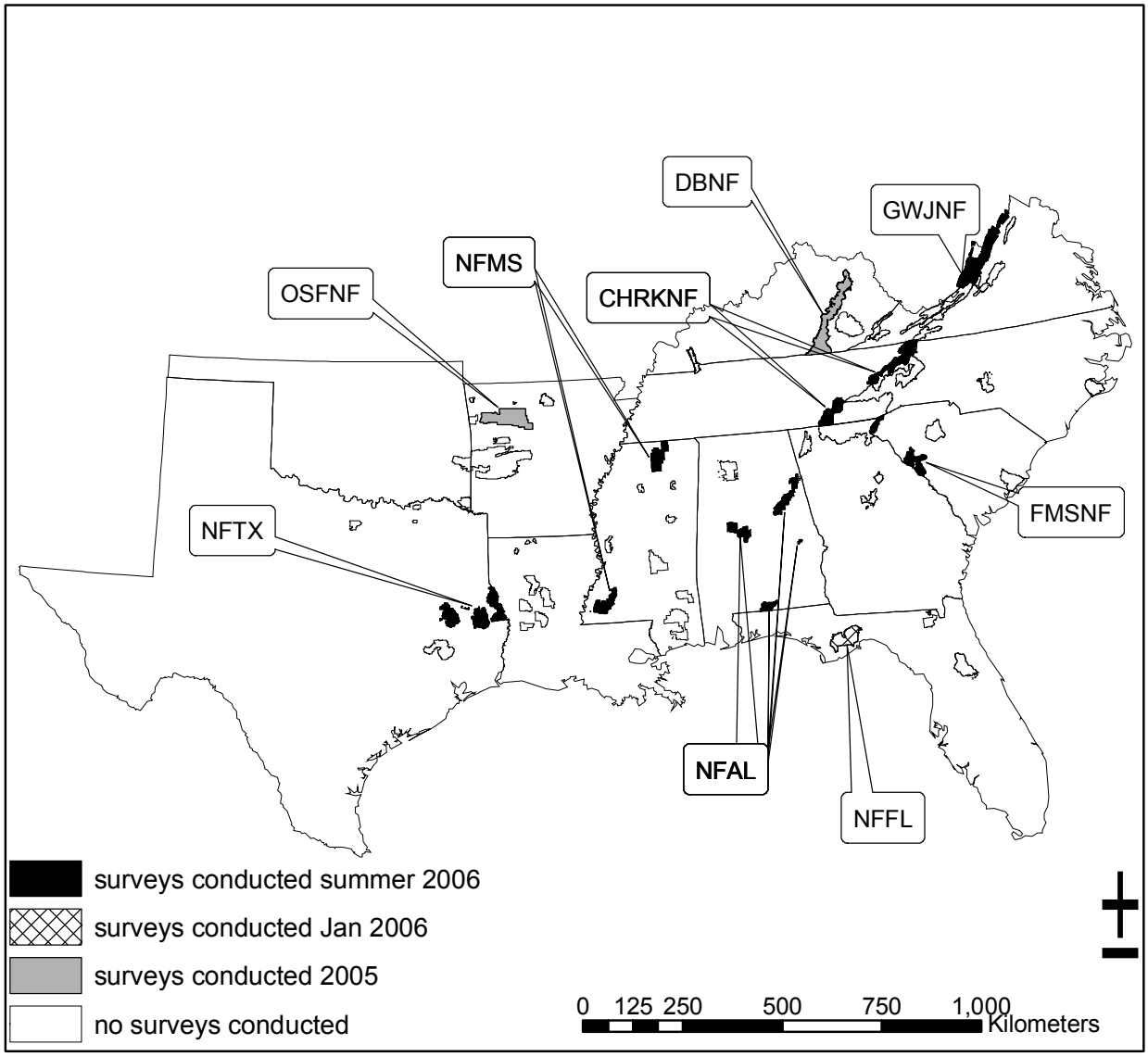

Figure 1. National Forests managed lands in the Southern Region. Crossing assessments were conducted between May and October 2006 in areas shaded black. GWJNF= George Washington-Jefferson National Forest, CHRKNF= Cherokee National Forest, NFMS= National Forests in Mississippi, NFAL= National Forests in Alabama, NFTX= National Forests in Texas, FMSNF= Francis Marion-Sumter National Forest. Crossing assessments were conducted in 2005 for National Forests shaded in gray (Coffman et al. 2005). The GWJNF and NFAL were surveyed in 2005 and 2006.

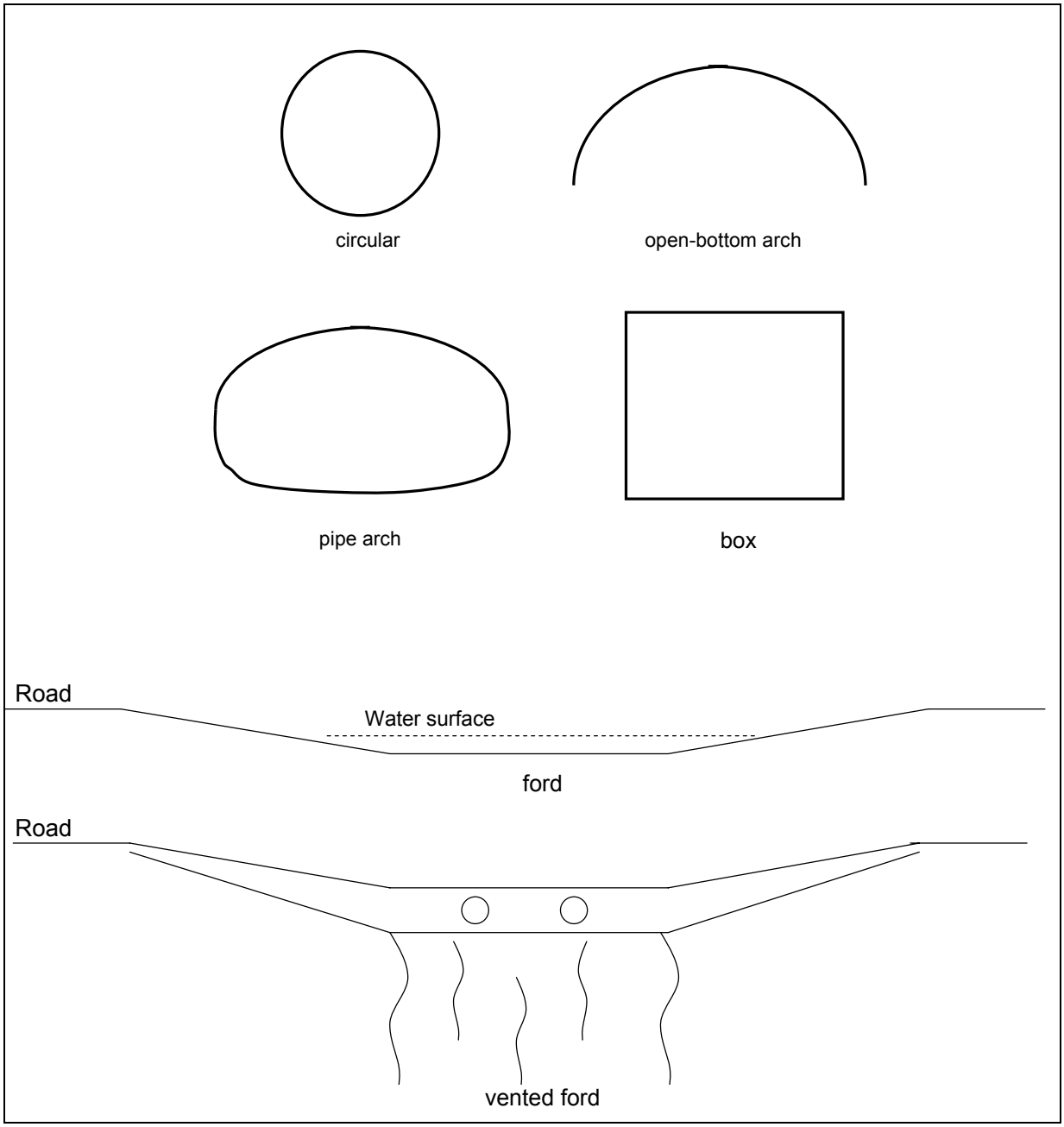

Figure 2. Common crossing shapes encountered during road-stream crossing inventories conducted in the Southern Region, summer 2006.

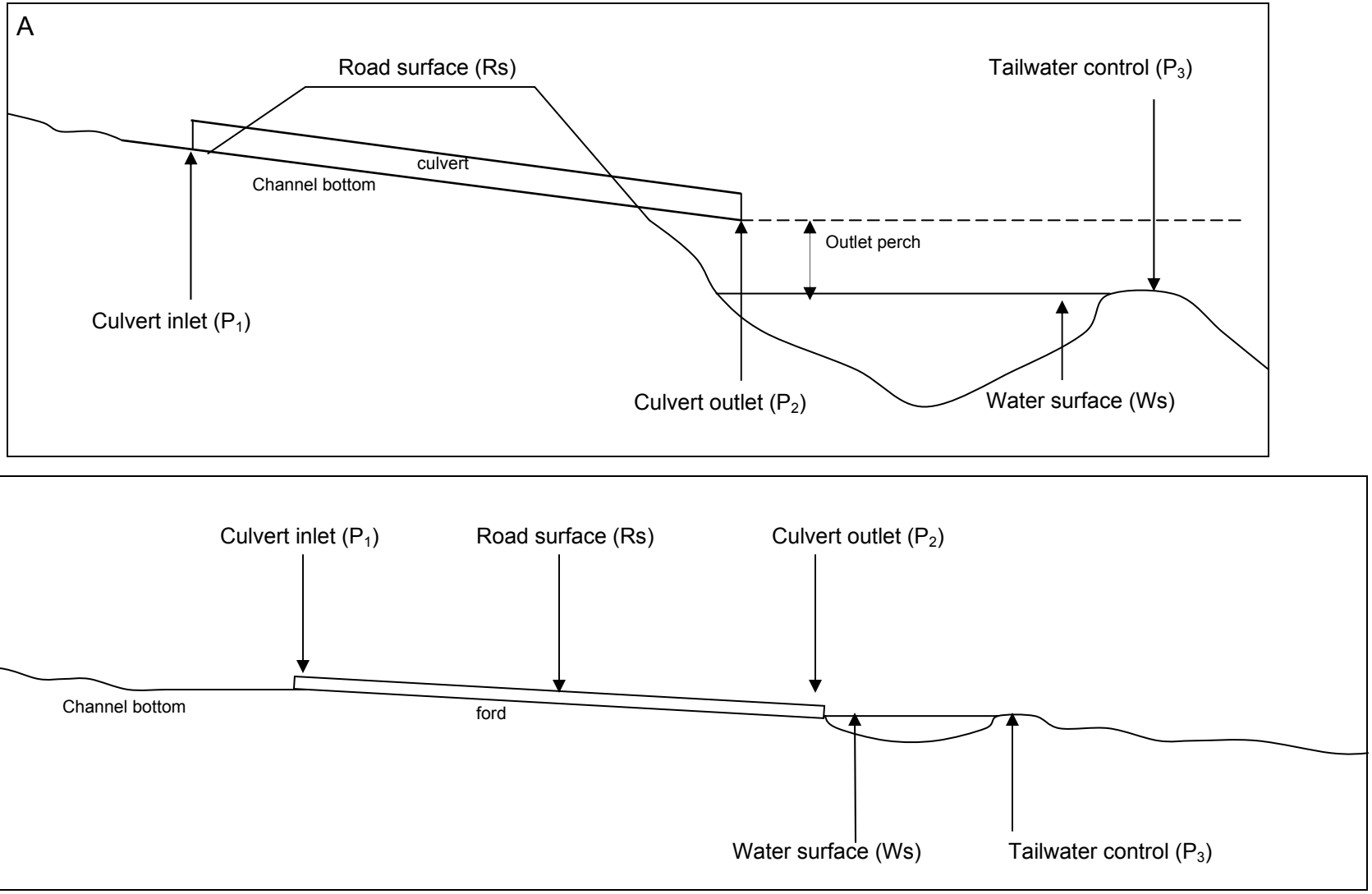

Figure 3. Survey points measured on culverts (A) and unvented fords (B) to calculate parameters used in coarse filters for upstream fish passage Adapted from Clarkin et al. 2003. Parameters are calculated as follows: Residual inlet depth= $P_3 - P_1$; Outlet drop= $P_2 - P_3$; Outlet perch= $P_2 -$ Ws; Slope= $(P_{1elev} - P_{2elev}) / (P_{1dist} - P_{2dist}) * 100$; Slope x Length= $[(P_{1elev} - P_{2elev}) / (P_{1dist} - P_{2dist}) * 100] * (P_{1dist} - P_{2dist})$.

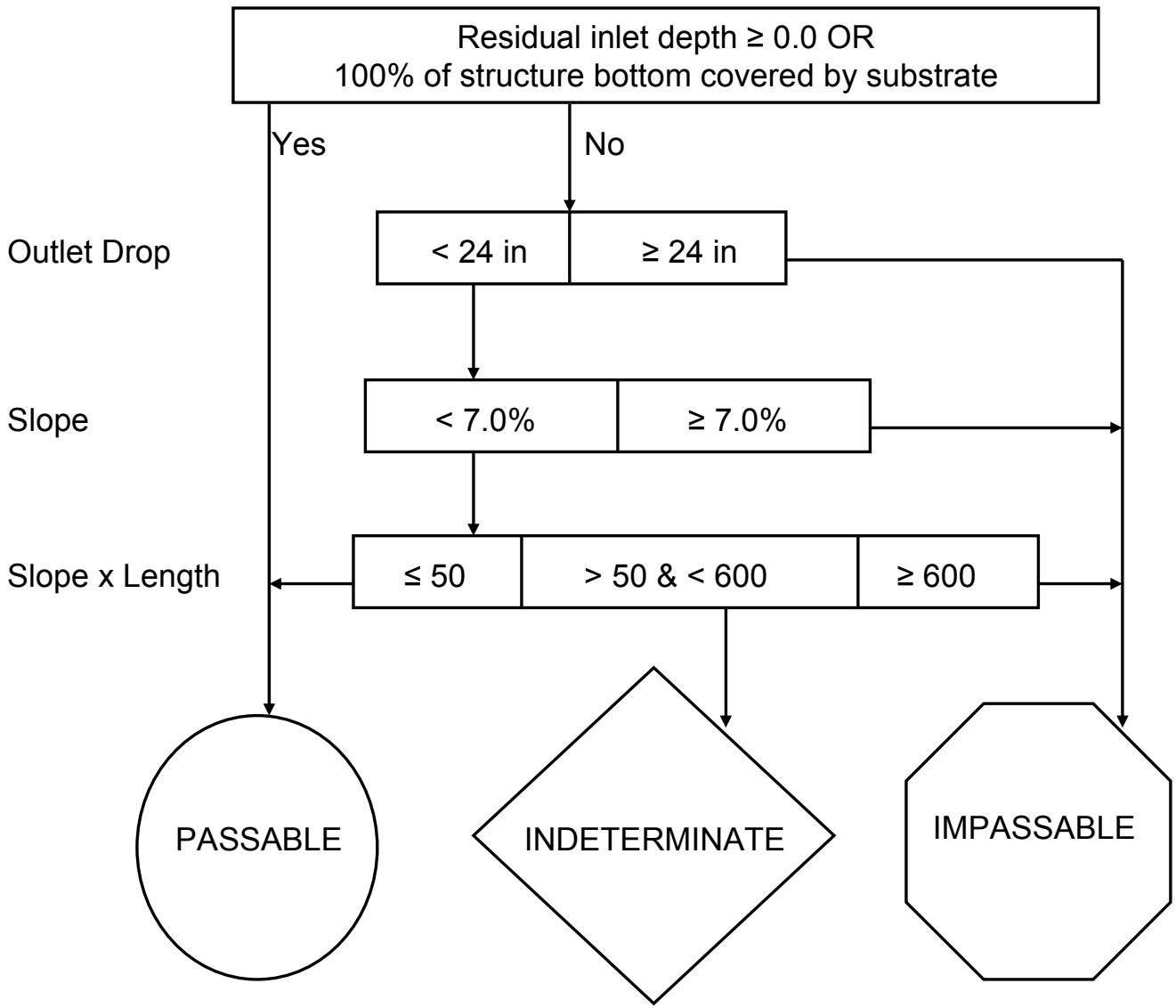

Figure 4. Coarse Filter A: Predictive model used to determine upstream passage for fish with swimming and leaping abilities similar to adult trout. A residual inlet depth ≥ 0.0 (Figure 2) indicates structure is fully backwatered. An outlet perch of 14 in is used when outlet drop could not be calculated (Coffman 2005).

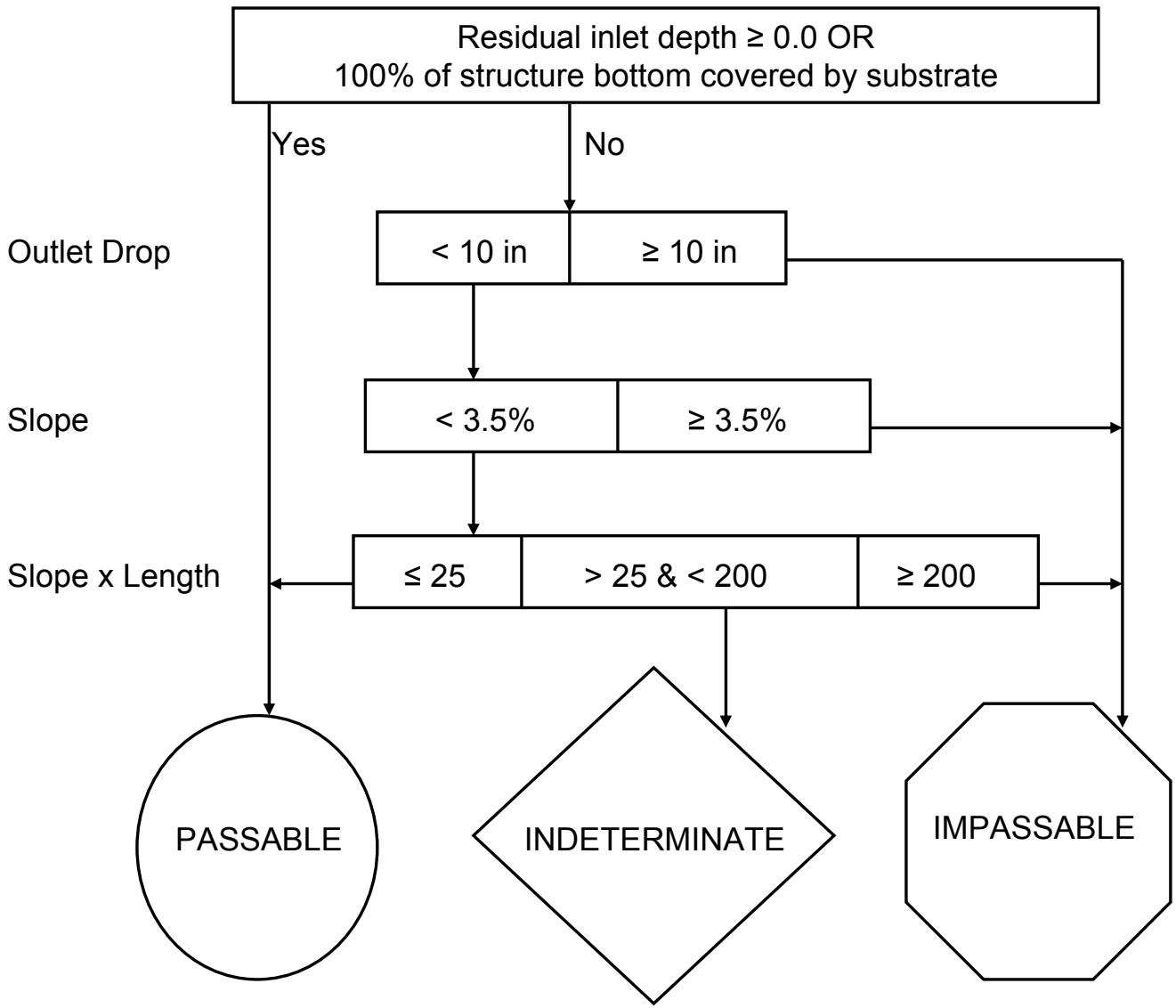

Figure 5. Coarse Filter B: Predictive model used to determine upstream passage for fish with swimming and leaping abilities similar to minnows and juvenile trout. A residual inlet depth ≥ 0.0 (Figure 2) indicates pipe is fully backwatered. An outlet perch of 5 in is used when outlet drop could not be calculated (Coffman 2005).

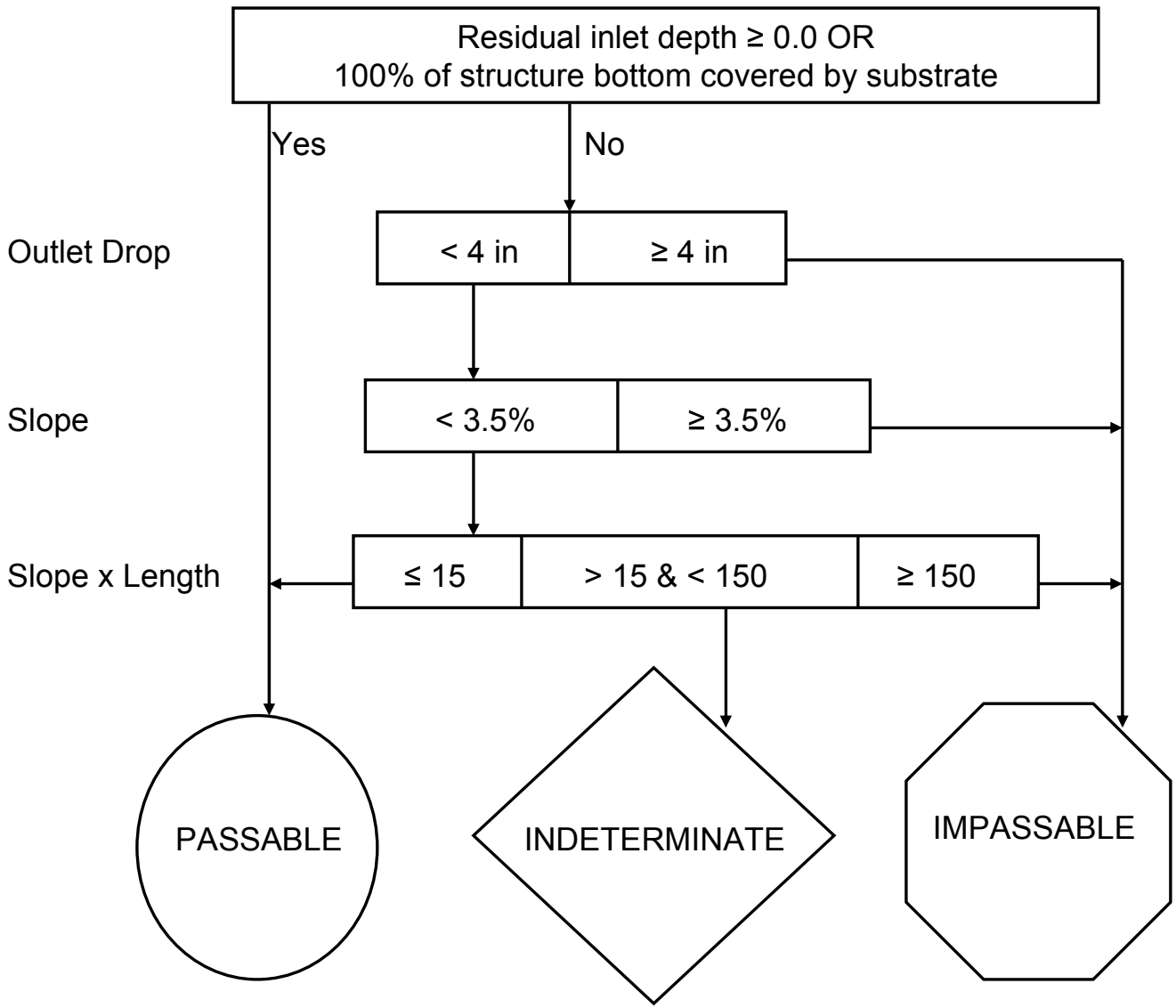

Figure 6. Coarse Filter C: Predictive model used to determine upstream passage for fish with swimming and leaping abilities similar to darters and sculpins. A residual inlet depth ≥ 0.0 (Figure 2) indicates pipe is fully backwatered. An outlet perch of 2 in is used when outlet drop could not be calculated (Coffman 2005).

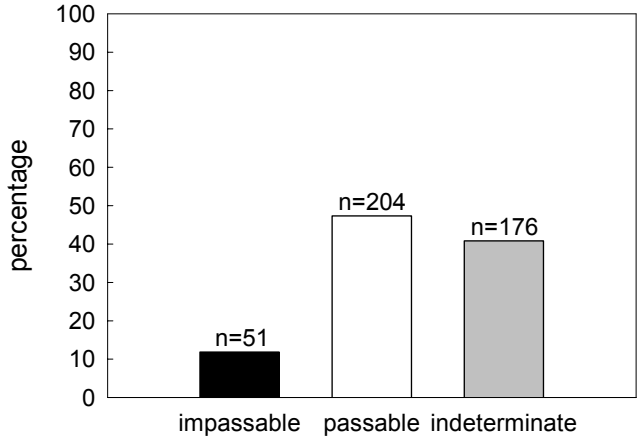

Figure 7. Percentage of crossings classified as impassable, passable, or indeterminate by Filter A; Southern Region (all Forests combined), summer 2006 (N=431).

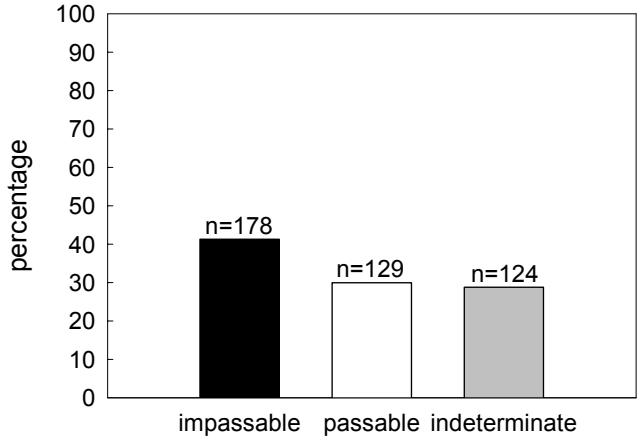

Figure 8. Percentage of crossings classified as impassable, passable, or indeterminate by Filter B; Southern Region (all Forests combined), summer 2006 (N=431).

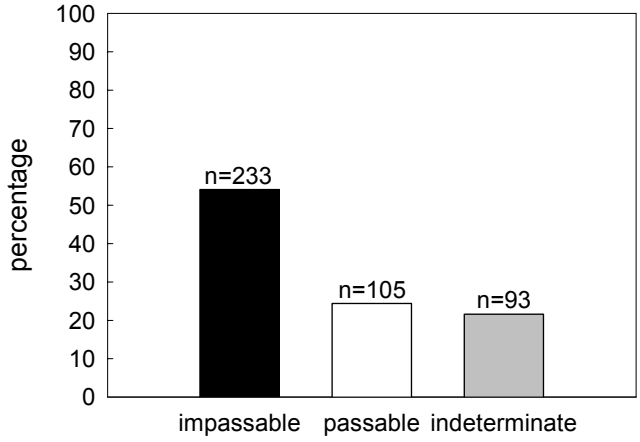

Figure 9. Percentage of crossings classified as impassable, passable, or indeterminate by Filter C; Southern Region (all Forests combined), summer 2006 (N=431).

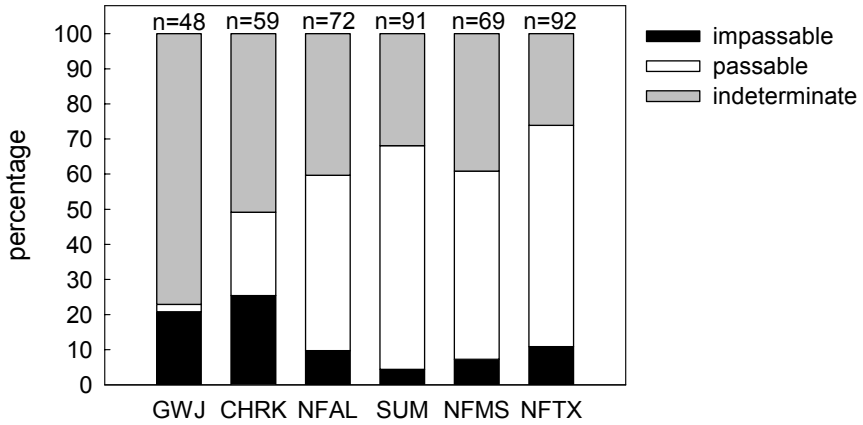

Figure 10. Percentage of crossings classified as impassable, passable, or indeterminate by Filter A; Southern Region (by Forest) summer 2006. GWJ=George Washington-Jefferson, CHRK=Cherokee, NFAL=National Forests in Alabama, SUM=Sumter, NFMS=National Forests in Mississippi, and NFTX=National Forests in Texas.

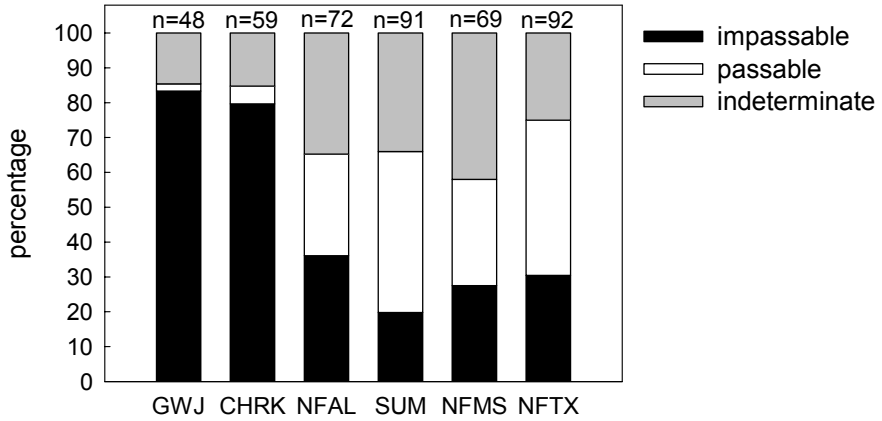

Figure 11. Percentage of crossings classified as impassable, passable, or indeterminate by Filter B; Southern Region (by Forest) summer 2006. GWJ=George Washington-Jefferson, CHRK=Cherokee, NFAL=National Forests in Alabama, SUM=Sumter, NFMS=National Forests in Mississippi, and NFTX=National Forests in Texas.

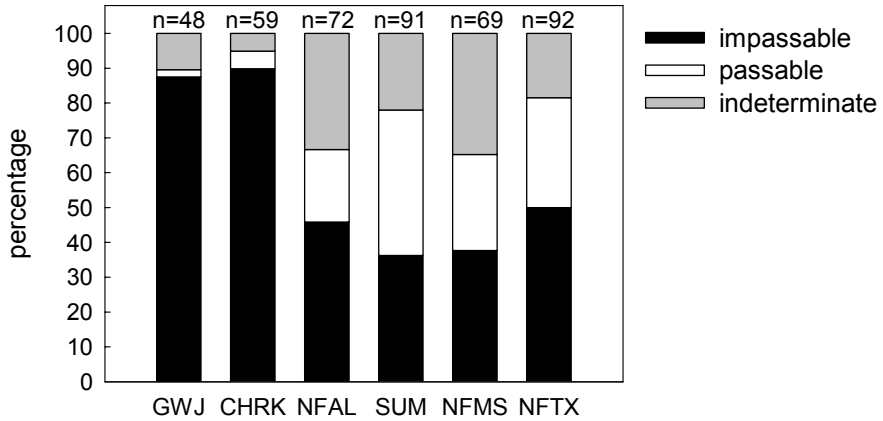

Figure 12. Percentage of crossings classified as impassable, passable, or indeterminate by Filter C; Southern Region (by Forest) summer 2006. GWJ=George Washington-Jefferson, CHRK=Cherokee, NFAL=National Forests in Alabama, SUM=Sumter, NFMS=National Forests in Mississippi, and NFTX=National Forests in Texas.

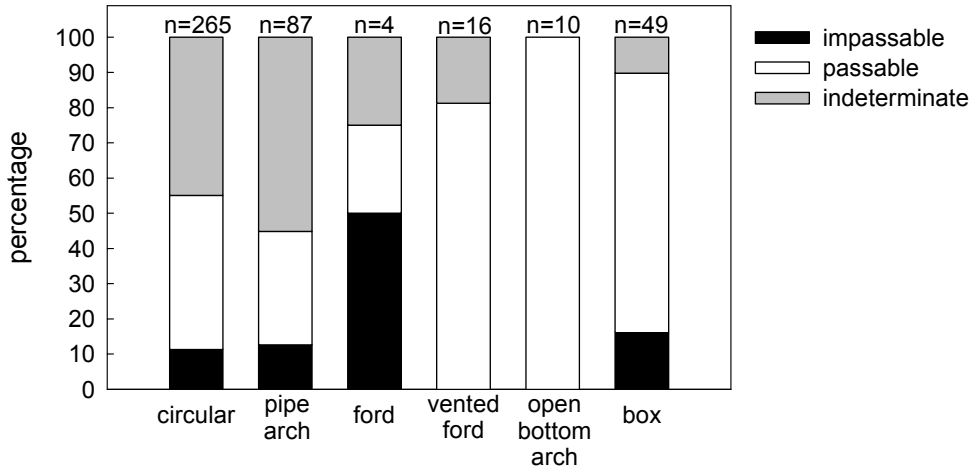

Figure 13. Percentage of each crossing type classified as impassable, passable, or indeterminate by Filter A; Southern Region (all Forests combined) summer 2006.

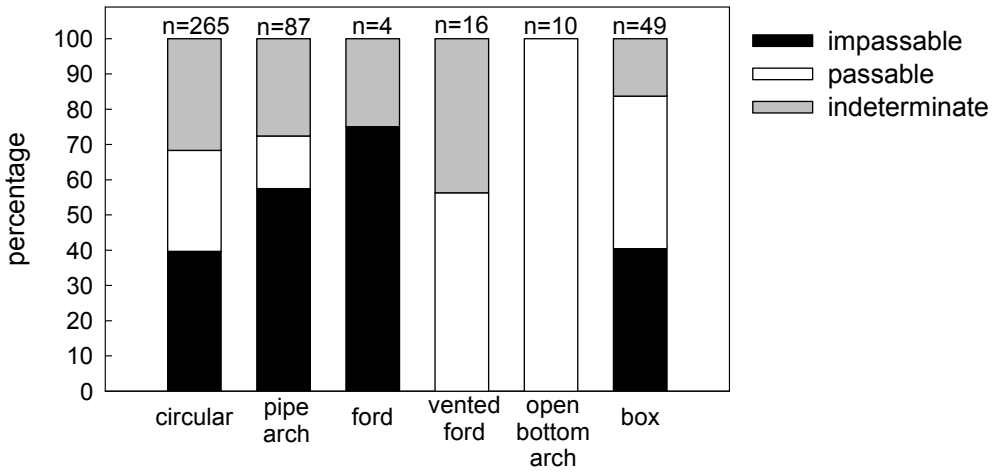

Figure 14. Percentage of each crossing type classified as impassable, passable, or indeterminate by Filter B; Southern Region (all Forests combined) summer 2006.

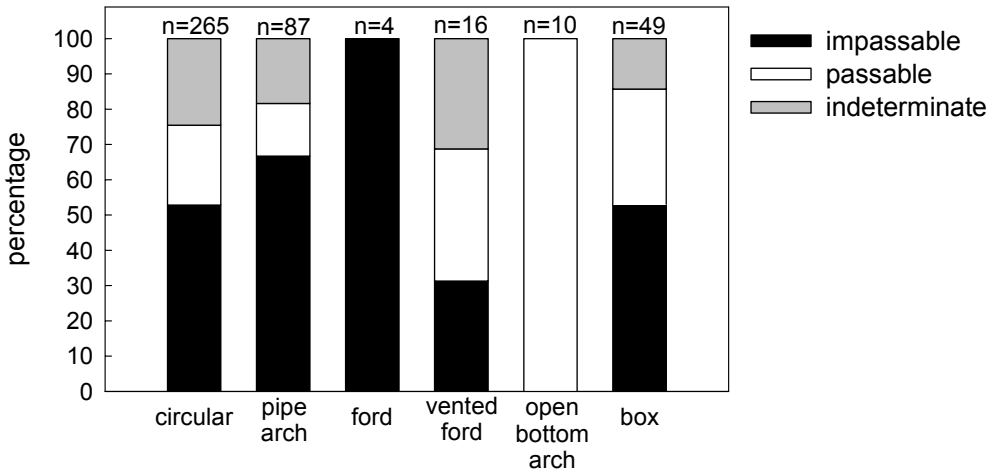

Figure 15. Percentage of each crossing type classified as impassable, passable, or indeterminate by Filter C; Southern Region (all Forests combined) summer 2006.

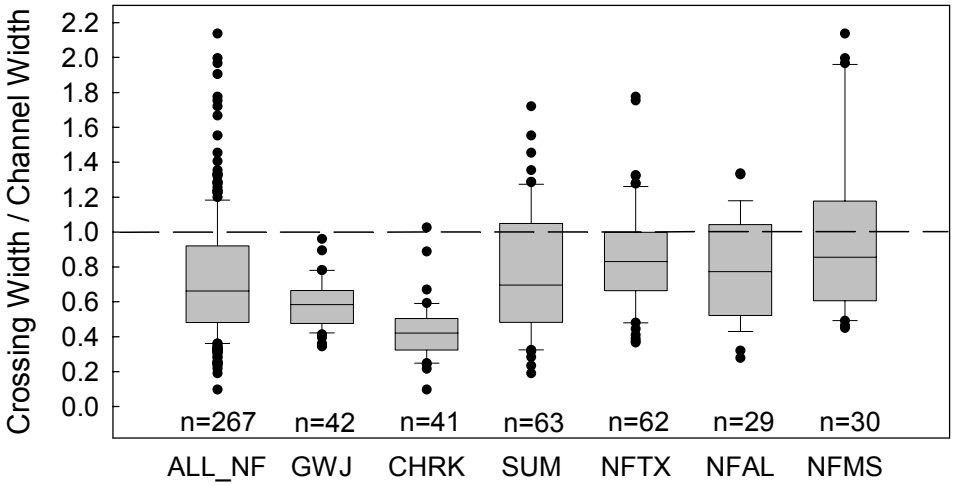

Figure 16. Crossing width to bankfull channel width ratio for crossings surveyed in summer 2006 (excluding fords, vented fords, and multiple structure crossings). A ratio of 1.0 (dashed line) or greater indicates the crossing structure opening is greater than or equal to the bankfull channel width. ALL_NF=Forests combined, GWJ=George Washington-Jefferson, CHRK=Cherokee, NFAL=National Forests in Alabama, SUM=Francis Marion-Sumter, NFMS=National Forests in Mississippi, and NFTX=National Forests in Texas. The top and bottom of the boxes represent the 25th and 75th percentiles, the bar in the center of each box represents the median, whiskers represent the 10th and 90th percentiles, and closed circles represent the entire range of the data.

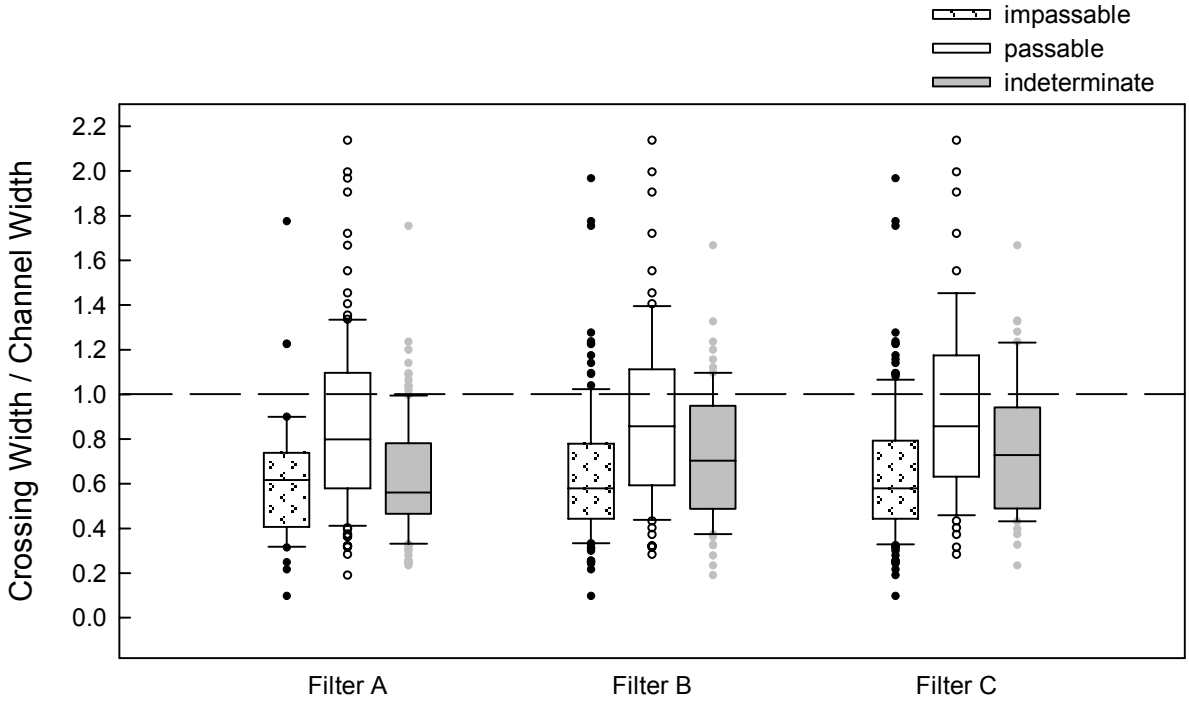

Figure 17. Crossing width to bankfull channel width ratio for crossings classified as impassable, passable, or indeterminate (all Forests combined) in summer 2006 (excluding fords, vented fords, and multiple structure crossings) A ratio of 1.0 (dashed line) or greater indicates the crossing structure opening is greater than or equal to the bankfull channel width. The top and bottom of the boxes represent the 25th and 75th percentiles, the bar in the center of each box represents the median, whiskers represent the 10th and 90th percentiles, and closed circles represent the entire range of the data.

Table 1. Number of crossings documented (Total crossings documented) and number not surveyed (Crossings not surveyed) on Forests visited in summer 2006. Reasons for not surveying a documented site include: no suitable fish habitat upstream of crossing (NH); no access to site due to closed roads or private gates (NA); crossing was a natural ford (NF); crossing was a bridge (BR).

Forest	Total crossings documented	Crossings not surveyed (n, [%])				
		NH	NA	NF	BR	Total not surveyed
GWJNF	66	14 (78)	0 (0)	4 (22)	0 (0)	18 (27)
CHRKNF	122	42 (67)	0 (0)	16 (25)	5 (8)	63 (52)
NFAL	103	14 (45)	0 (0)	0 (0)	17 (55)	31 (30)
FMSNF	120	18 (62)	7 (24)	4 (14)	0 (0)	29 (24)
NFMS	96	14 (52)	1 (4)	11 (40)	1 (4)	27 (28)
NFTX	126	31 (91)	1 (3)	1 (3)	1 (3)	34 (27)
Total	633	133 (66)	9 (4)	36 (18)	24 (12)	202 (32)

Table 2. Number of crossings surveyed (Total surveyed) with coarse filter results for Forests visited in summer 2006. Coarse filter results are presented for Filter A, Filter B, and Filter C (see filter descriptions, Fig 3 – 5).

Forest	Total surveyed	Coarse filter results								
		Impassable (n, [%])			Passable (n, [%])			Indeterminate (n, [%])		
		A	B	C	A	B	C	A	B	C
GWJNF	48	10 (21)	40 (83)	42 (88)	1 (2)	1 (2)	1 (2)	37 (77)	7 (15)	5 (10)
CHRKNF	59	15 (25)	47 (80)	53 (90)	14 (24)	3 (5)	3 (5)	30 (51)	9 (15)	3 (5)
NFAL	72	7 (10)	26 (36)	33 (46)	36 (50)	21 (29)	15 (21)	29 (40)	25 (35)	24 (33)
FMSNF	91	4 (4)	18 (20)	33 (36)	58 (64)	42 (46)	38 (42)	29 (32)	31 (34)	20 (22)
NFMS	69	5 (7)	19 (28)	26 (38)	37 (54)	21 (30)	19 (27)	27 (39)	29 (42)	24 (35)
NFTX	92	10 (11)	28 (30)	46 (50)	58 (63)	41 (45)	29 (32)	24 (26)	23 (25)	17 (18)
Total	431	51 (12)	178 (41)	233 (54)	204 (47)	129 (30)	105 (24)	176 (41)	124 (29)	93 (22)

Table 3. Number of crossings (percentage in parentheses) classified as impassable due to excessive outlet drop, excessive slope, or excessive slope x length values for each coarse filter; Southern Region (all Forests combined), summer 2006. Note: a crossing must pass for outlet drop to be considered for slope and it must pass for outlet drop and slope to be considered for slope*length.

	Filter A	Filter B	Filter C
Outlet drop	36 (69)	147 (82)	215 (91)
Slope	15 (31)	31 (18)	17 (8)
Slope*Length	0 (0)	0 (0)	1 (1)
Total	51 (12)	178 (41)	233 (54)

Table 4. Number of each crossing type (percentage in parentheses) classified as impassable, passable, or indeterminate for each coarse filter; Southern Region (all Forests combined) during summer 2006.

Classification	crossing type	Filter A	Filter B	Filter C
Impassable	circular	30 (11)	105 (39)	140 (53)
	pipe arch	11 (13)	50 (57)	58 (67)
	vented ford	0 (0)	0 (0)	5 (31)
	ford	2 (50)	3 (75)	4 (100)
	open bottom arch	0 (0)	0 (0)	0 (0)
	box	8 (16)	20 (41)	26 (53)
Passable	circular	116 (43)	76 (29)	60 (23)
	pipe arch	28 (32)	13 (15)	13 (15)
	vented ford	13 (81)	9 (56)	6 (38)
	ford	1 (25)	0 (0)	0 (0)
	open bottom arch	10 (100)	10 (100)	10 (100)
	box	36 (74)	21 (43)	16 (33)
Indeterminate	circular	119 (45)	84 (32)	65 (24)
	pipe arch	48 (55)	24 (28)	16 (18)
	vented ford	3 (19)	7 (44)	5 (31)
	ford	1 (25)	1 (25)	0 (0)
	open bottom arch	0 (0)	0 (0)	0 (0)
	box	5 (10)	8 (16)	7 (14)

Table 5. Mean Crossing width to channel width ratios (excluding fords, vented fords, and multiple structure crossings) for impassable, passable, and indeterminate classifications by each filter (Figures 4-6). Letters denote significant differences (ANOVA; P<0.05)

Filter A	$\bar{x}$	SD	n
Impassable	0.62 z	0.30	41
Passable	0.87 zy	0.40	112
Indeterminate	0.63 y	0.25	114
Filter B			
Impassable	0.64 x	0.30	126
Passable	0.90 x	0.41	71
Indeterminate	0.73 x	0.29	70
Filter C			
Impassable	0.65 wv	0.30	158
Passable	0.93 w	0.41	59
Indeterminate	0.77 v	0.30	50

Appendix A: Results for the George Washington-Jefferson National Forest

We completed surveys at 48 (73%) of 66 documented crossing structures on the Warm Springs and James River Ranger Districts in 2006 (Figure A1, Tables A1 and A2). Filter A (strong swimmers and leapers) classified 21% (n=10) of crossings as impassable, 2% (n=1) as passable, and 77% (n=37) as indeterminate (Figure A2, Table A2). Filter B (moderate swimmers and leapers) classified 83% (n=40) of crossings as impassable, 2% (n=1) as passable, and 15% (n=7) as indeterminate (Figure A3, Table A2). Filter C (weak swimmers and leapers) classified 88% (n=42) of crossings as impassable, 2% (n=1) as passable, and 10% (n=5) as indeterminate (Figure A4, Table A2). Characteristics and filter classifications for each crossing are presented in Tables A3-A5.

All of the crossings surveyed were either circular culverts (29%, n=14) or pipe arches (71%, n=34), while no open-bottom arches, fords, vented fords, or box culverts were surveyed. Filter A classified 36% of circular culverts and 15% of pipe arch crossings as impassable (Figure A5). Filter B classified 86% of circular culverts and 82% of pipe arch crossings as impassable (Figure A6). Filter C classified 93% of circular culverts and 85% of pipe arch crossings as impassable (Figure A7). The mean crossing width to channel width ratio for surveyed crossings (excluding fords and multiple structure crossings) was 0.59 ± 0.14 (mean ±SD) (n=42), and no crossings were greater than or equal to the mean bankfull channel width (Figure A8). The mean crossing width to channel width ratio for surveyed crossings classified impassable by Filter A was 0.58 ± 0.17 (n=10). The mean ratio for crossings classified impassable by Filter B was 0.58 ± 0.14 (n=37), and was 0.59 ± 0.15 (n=39) for Filter C (Figure A9). There were no crossings classified passable that met the requirements to calculate crossing to channel width ratios.

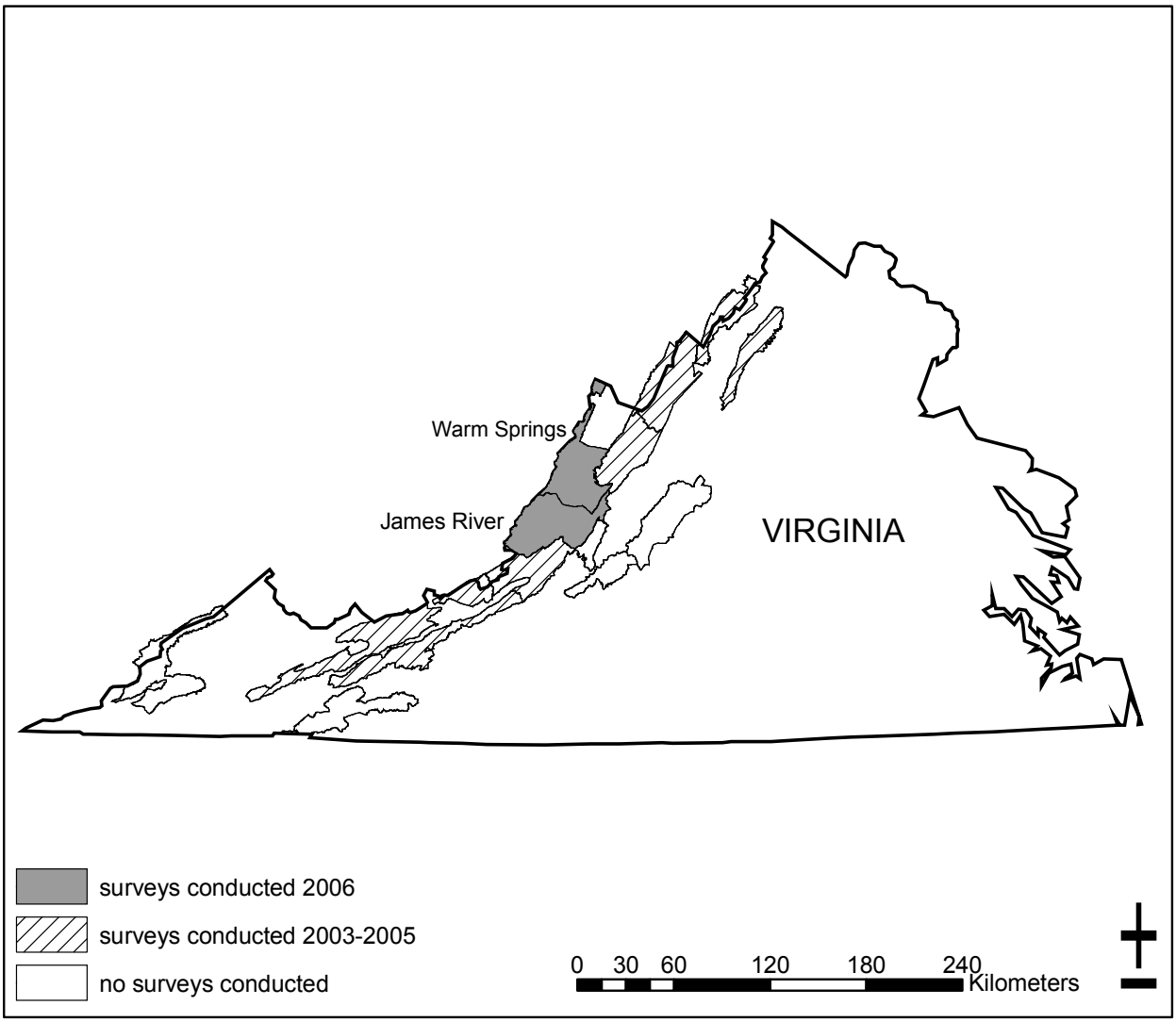

Figure A1. Ranger Districts on the George Washington-Jefferson National Forest where road-stream crossing surveys were conducted from 2003 to 2006. The results of inventories conducted by Fish and Aquatic Ecology Unit - East on Dry River and Lee Ranger Districts in 2003-2004 are presented in Coffman et al. 2007, and the results from 2005 surveys are presented in Coffman et al. 2005.

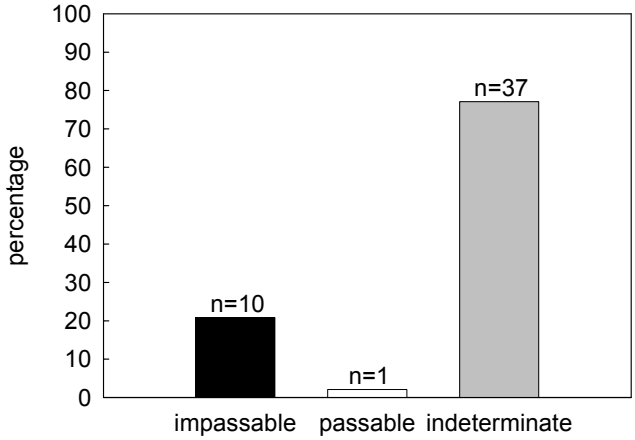

Figure A2. Percentage of crossings classified as impassable, passable, or indeterminate by Filter A; George Washington-Jefferson National Forest, summer 2006 (n=48).

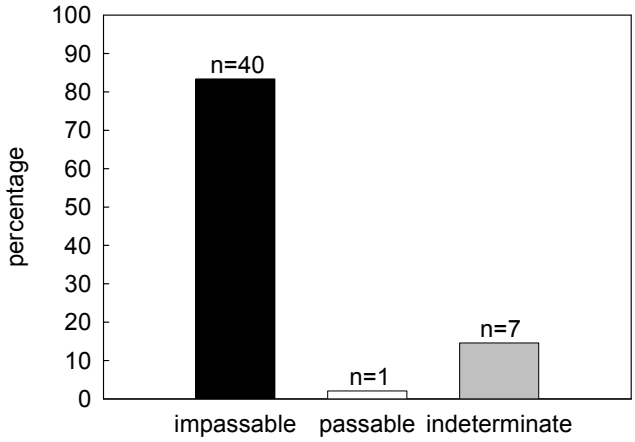

Figure A3. Percentage of crossings classified as impassable, passable, or indeterminate by Filter B; George Washington-Jefferson National Forest, summer 2006 (n=48).

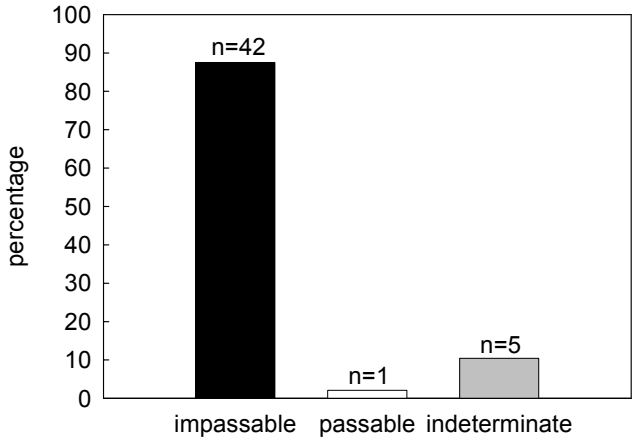

Figure A4. Percentage of crossings classified as impassable, passable, or indeterminate by Filter C; George Washington-Jefferson National Forest, summer 2006 (n=48).

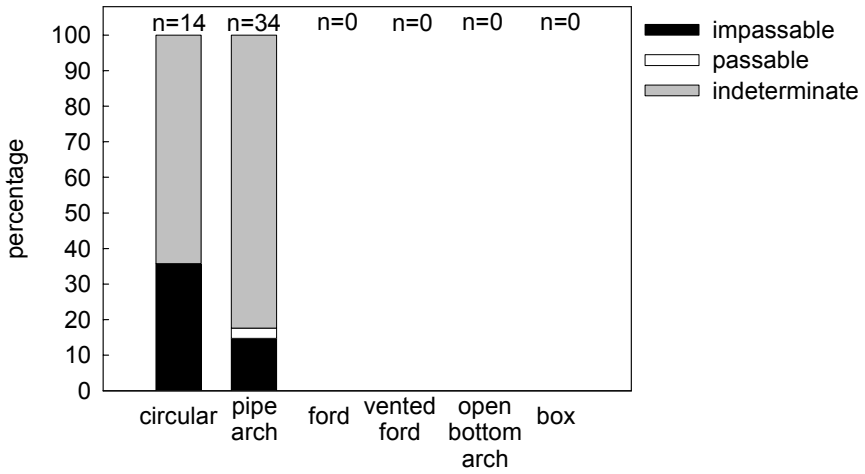

Figure A5. Percentage of each crossing type classified as impassable, passable, or indeterminate by Filter A; George Washington-Jefferson National Forest, summer 2006 (N=48).

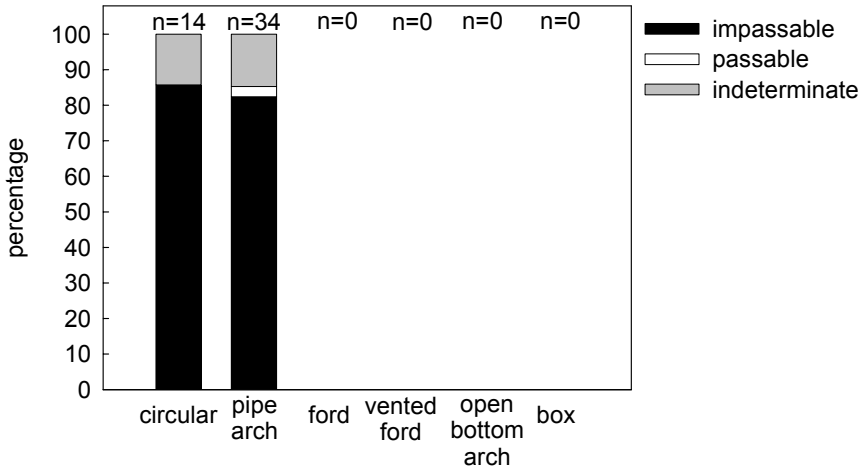

Figure A6. Percentage of each crossing type classified as impassable, passable, or indeterminate by Filter B; George Washington-Jefferson National Forest, summer 2006 (N=48).

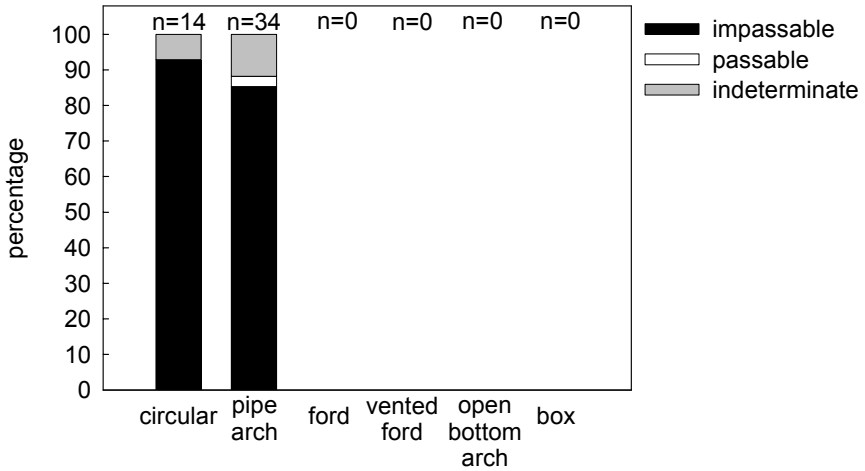

Figure A7. Percentage of each crossing type classified as impassable, passable, or indeterminate by Filter C; George Washington-Jefferson National Forest, summer 2006 (N=48).

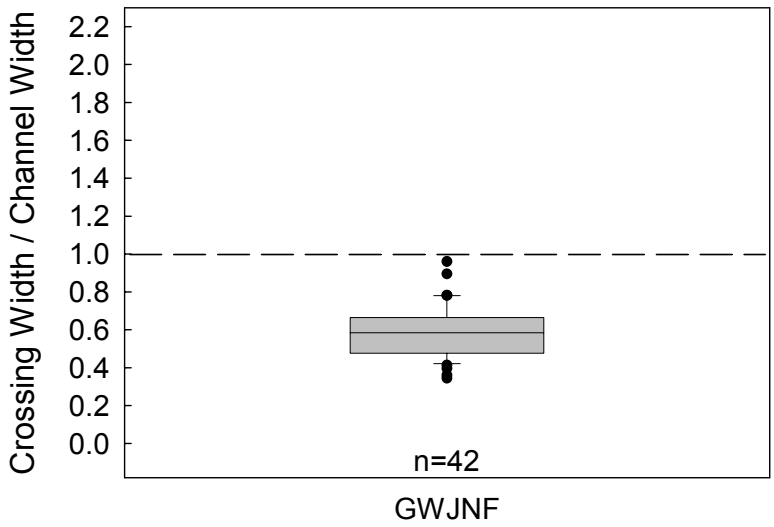

Figure A8. Crossing width to bankfull channel width ratio for crossings surveyed in summer 2006 on the George Washington-Jefferson National Forest (excluding fords, vented fords, and multiple structure crossings). A ratio of 1.0 (dashed line) or greater indicates the crossing structure opening is greater than or equal to the bankfull channel width. The top and bottom of the boxes represent the 25th and 75th percentiles, the bar in the center of each box represents the median, whiskers represent the 10th and 90th percentiles, and closed circles represent the entire range of the data.

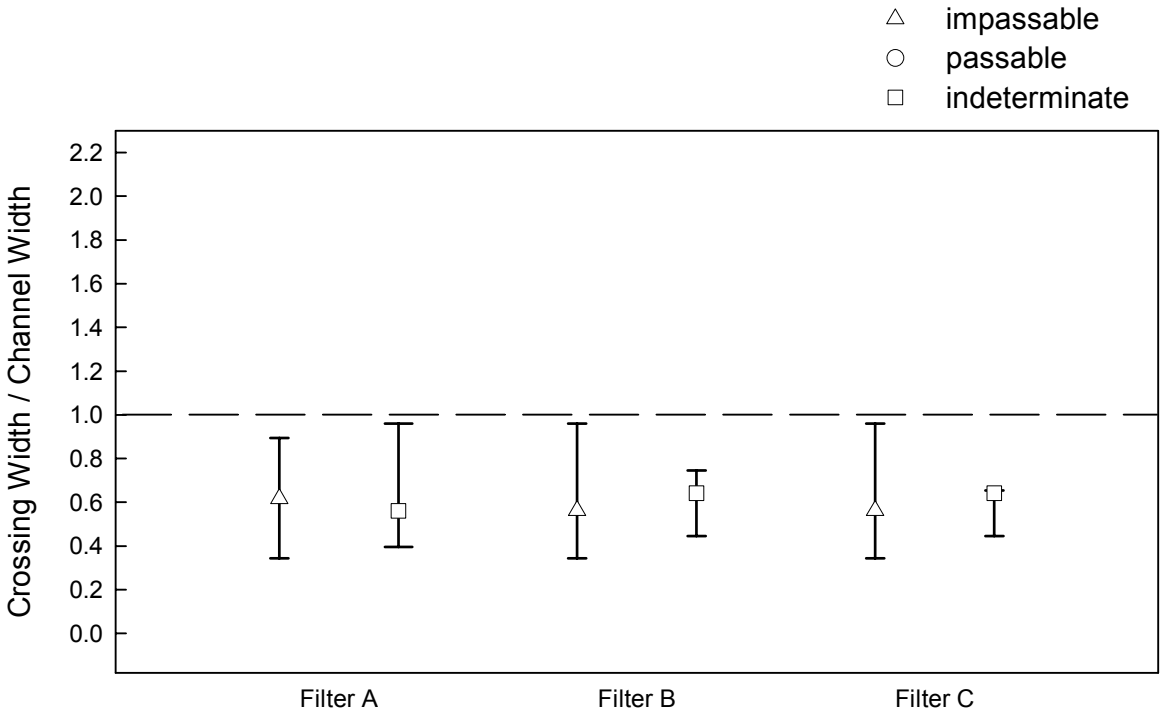

Figure A9. Crossing width to bankfull channel width ratio for crossings classified as impassable, passable, or indeterminate in summer 2006 on the George Washington-Jefferson National Forest (excluding fords, vented fords, and multiple structure crossings). A ratio of 1.0 (dashed line) or greater indicates the crossing structure opening is greater than or equal to the bankfull channel width. The symbol inside each set of whiskers represents the median, and the top and bottom of the whiskers represent the maximum and minimum values.

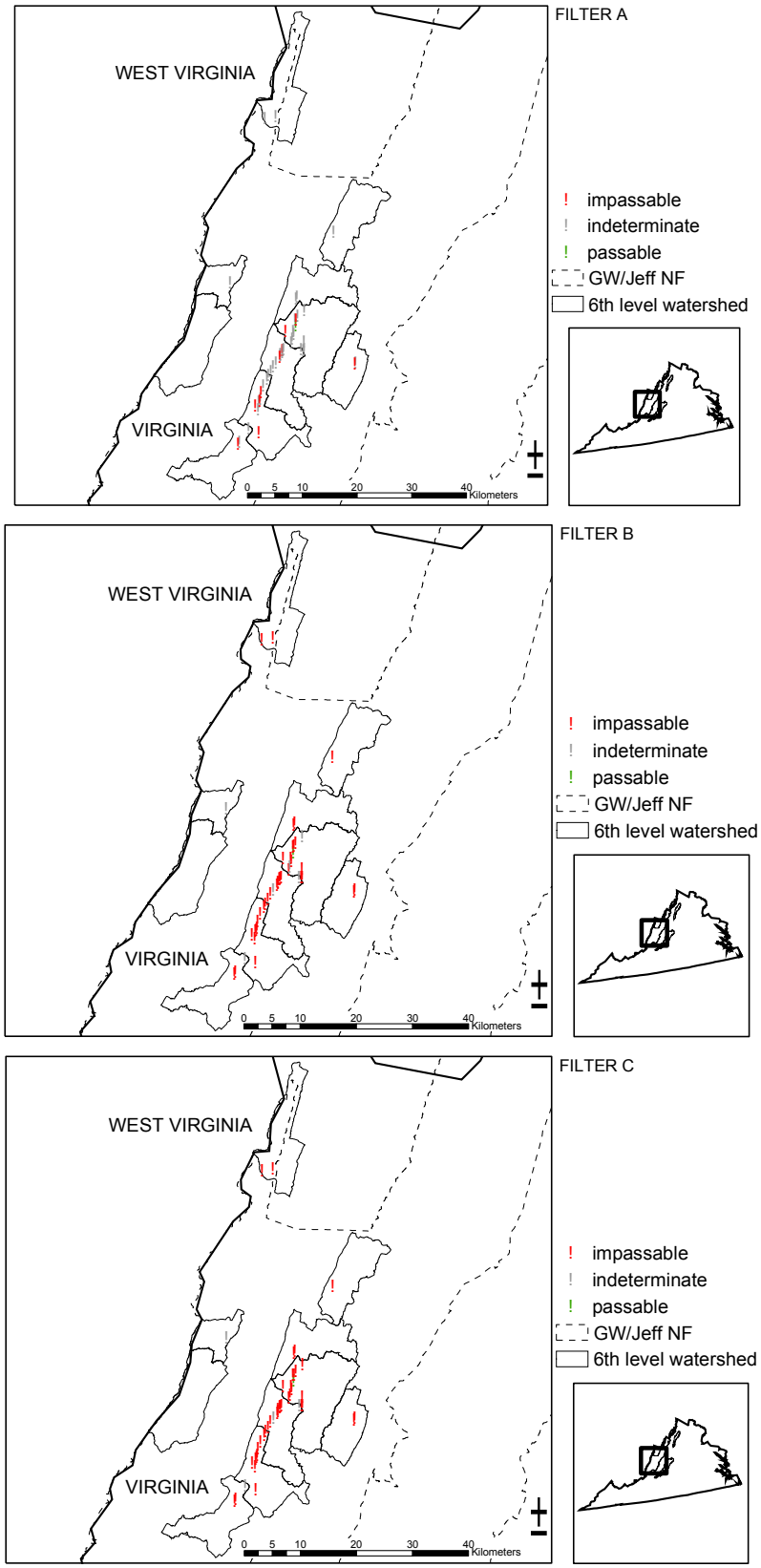

Figure A10. Location of crossings classified for fish passage by coarse filters A, B, and C within 6th level watersheds on the George Washington-Jefferson National Forest, summer 2006.

Table A1. Number of crossings documented (Total crossings documented) and not surveyed (Crossings not surveyed) on the George Washington-Jefferson National Forests in summer 2006. Reasons for not surveying a documented site include: no suitable fish habitat upstream of crossing (NH); no access to site due to closed roads or private gates (NA); crossing was a natural ford (NF); crossing was a bridge (BR).

Forest	Total crossings documented	Crossings not surveyed (n, [%])				
		NH	NA	NF	BR	Total not surveyed
GWJNF	66	14 (78)	0 (0)	4 (22)	0 (0)	18 (27)

Table A2. Number of crossings surveyed (Total surveyed) with coarse filter results for the George Washington-Jefferson National Forests in summer 2006. Coarse filter results are presented for Filter A, Filter B, and Filter C (see filter descriptions, Fig 3 – 5).

Forest	Total surveyed	Coarse filter results								
		Impassable (n, [%])			Passable (n, [%])			Indeterminate (n, [%])		
		A	B	C	A	B	C	A	B	C
GWJNF	48	10 (21)	40 (83)	42 (88)	1 (2)	1 (2)	1 (2)	37 (77)	7 (15)	5 (10)

Table A3. Location of crossings surveyed on the George Washington-Jefferson National Forest during the summer of 2006. Site ID consists of the Forest abbreviation (GWJ), road the crossing is on (258), and the distance (miles) from the junction road (0.2).

Site ID	# of Pipes	District	Junction Road	Stream Name	Quad	6th Level Watershed
GWJ258-0.2	1	Warm Springs	600	Sheets Hollow	Mustoe	020802010201
GWJ258-3.4	2	Warm Springs	600	Ruckman Draft	Paddy Knob	020802010201
GWJ226-0.1	2	Warm Springs	39	O'Roarke Draft	Mountain Grove	020802010204
GWJ125-1.2	1	James River	625	UT Pounding Mill Creek	Covington	020802010504
GWJ125-1.5	1	James River	625	UT Pounding Mill Creek	Covington	020802010504
GWJ125-4.8	1	James River	625	Piney Branch	Covington	020802010504
GWJ125-5.0	1	Warm Springs	606	Left Prong Wilson Creek	Healing Springs	020802010506
GWJ125-5.8	1	Warm Springs	606	UT Left Prong Wilson Creek	Healing Springs	020802010506
GWJ125-6.4	1	Warm Springs	606	Lick Block Run	Healing Springs	020802010506
GWJ125-7.2	1	Warm Springs	606	UT Left Prong Wilson Creek	Healing Springs	020802010506
GWJ125-7.4	1	Warm Springs	606	UT Left Prong Wilson Creek	Healing Springs	020802010506
GWJ125-7.6	1	Warm Springs	606	UT Left Prong Wilson Creek	Healing Springs	020802010506
GWJ125-7.9	1	Warm Springs	606	UT Left Prong Wilson Creek	Healing Springs	020802010506
GWJ125-8.1	1	Warm Springs	606	UT Left Prong Wilson Creek	Healing Springs	020802010506
GWJ125-8.2	1	Warm Springs	606	UT Left Prong Wilson Creek	Healing Springs	020802010506
GWJ125-8.4	1	Warm Springs	606	UT Left Prong Wilson Creek	Healing Springs	020802010506
GWJ361A-0.1	1	Warm Springs	361	Dry Run	Healing Springs	020802010506
GWJ125-0.2	1	James River	606	UT Piney Branch	Covington	020802010507
GWJ125-1.0	1	James River	606	UT Smith Creek	Clifton Forge	020802010507
GWJ125-1.1	1	James River	606	UT Smith Creek	Clifton Forge	020802010507
GWJ125-1.4	1	James River	606	UT Smith Creek	Healing Springs	020802010507
GWJ125-2.2	1	James River	606	UT Smith Creek	Healing Springs	020802010507
GWJ125-3.2	1	Warm Springs	606	UT Smith Creek	Healing Springs	020802010507
GWJ125-4.0	1	Warm Springs	606	UT Smith Creek	Healing Springs	020802010507
GWJ125-4.4	1	Warm Springs	606	Smith Creek	Healing Springs	020802010507

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Site ID	# of Pipes	District	Junction Road	Stream Name	Quad	6th Level Watershed
GWJ125-5.9	1	James River	625	UT Piney Branch	Clifton Forge	020802010507
GWJ337-3.5	1	James River	606	UT Jackson River	Covington	020802010507
GWJ1144-2.0	1	Warm Springs	624	UT Wide Draft Hollow	Bath Alum	020802010701
GWJ364-1.4	1	Warm Springs	39	Barney Run	Warm Springs	020802010703
GWJ364-1.6	1	Warm Springs	39	UT Mare Run	Warm Springs	020802010703
GWJ1901-2.9	1	Warm Springs	194	Porters Mill Creek	Healing Springs	020802010801
GWJ194-1.1	1	Warm Springs	629	Slim Ridge Branch	Healing Springs	020802010801
GWJ194-1.7	1	Warm Springs	629	UT Porters Mill Creek	Healing Springs	020802010801
GWJ194-2.7	1	Warm Springs	629	UT Porters Mill Creek	Healing Springs	020802010801
GWJ194-3.0	1	Warm Springs	629	Porters Mill Creek	Healing Springs	020802010801
GWJ194-3.9	2	Warm Springs	629	Little Wilson Creek	Healing Springs	020802010801
GWJ194-5.0	1	Warm Springs	629	Stouts Creek	Healing Springs	020802010801
GWJ194-5.1	1	Warm Springs	629	UT Stouts Creek	Healing Springs	020802010801
GWJ194-5.7	1	Warm Springs	629	UT Stouts Creek	Healing Springs	020802010801
GWJ194-7.4	1	Warm Springs	629	UT Limekiln Hollow	Bath Alum	020802010801
GWJ361-0.45	1	Warm Springs	629	Gillam Run	Healing Springs	020802010801
GWJ361-1.7	1	Warm Springs	629	UT Gillam Run	Healing Springs	020802010801
GWJ361-1.9	1	Warm Springs	629	Gillam Run	Healing Springs	020802010801
GWJ129-2.9	1	Warm Springs	633	UT South Fork	Nimrod Hall	020802010802
GWJ129-3.1	1	Warm Springs	633	UT South Fork	Nimrod Hall	020802010802

Table A4. Coarse filter A, B, and C, classifications for crossings surveyed on the George Washington-Jefferson National Forest, summer 2006.

Site ID	Pipe #	Filter A	Filter B	Filter C
GWJ258-0.2	1	indeterminate	impassable	impassable
GWJ258-3.4	1	indeterminate	impassable	impassable
GWJ258-3.4	2	indeterminate	impassable	impassable
GWJ226-0.1	1	indeterminate	indeterminate	indeterminate
GWJ226-0.1	2	indeterminate	impassable	impassable
GWJ125-1.2	1	impassable	impassable	impassable
GWJ125-1.5	1	indeterminate	impassable	impassable
GWJ125-4.8	1	indeterminate	indeterminate	indeterminate
GWJ125-5.0	1	indeterminate	impassable	impassable
GWJ125-5.8	1	indeterminate	impassable	impassable
GWJ125-6.4	1	indeterminate	indeterminate	indeterminate
GWJ125-7.2	1	impassable	impassable	impassable
GWJ125-7.4	1	indeterminate	impassable	impassable
GWJ125-7.6	1	indeterminate	impassable	impassable
GWJ125-7.9	1	indeterminate	impassable	impassable
GWJ125-8.1	1	impassable	impassable	impassable
GWJ125-8.2	1	indeterminate	impassable	impassable
GWJ125-8.4	1	indeterminate	impassable	impassable
GWJ361A-0.1	1	indeterminate	indeterminate	indeterminate
GWJ125-0.2	1	impassable	impassable	impassable
GWJ125-1.0	1	indeterminate	impassable	impassable
GWJ125-1.1	1	impassable	impassable	impassable
GWJ125-1.4	1	indeterminate	impassable	impassable
GWJ125-2.2	1	impassable	impassable	impassable
GWJ125-3.2	1	indeterminate	impassable	impassable
GWJ125-4.0	1	indeterminate	impassable	impassable
GWJ125-4.4	1	indeterminate	impassable	impassable
GWJ125-5.9	1	indeterminate	impassable	impassable
GWJ337-3.5	1	impassable	impassable	impassable
GWJ1144-2.0	1	indeterminate	impassable	impassable
GWJ364-1.4	1	indeterminate	impassable	impassable
GWJ364-1.6	1	indeterminate	impassable	impassable
GWJ1901-2.9	1	impassable	impassable	impassable
GWJ194-1.1	1	indeterminate	impassable	impassable
GWJ194-1.7	1	indeterminate	indeterminate	impassable
GWJ194-2.7	1	indeterminate	impassable	impassable
GWJ194-3.0	1	indeterminate	impassable	impassable
GWJ194-3.9	1	indeterminate	indeterminate	indeterminate
GWJ194-3.9	2	passable	passable	passable

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Site ID	Pipe #	Filter A	Filter B	Filter C
GWJ194-5.0	1	indeterminate	impassable	impassable
GWJ194-5.1	1	impassable	impassable	impassable
GWJ194-5.7	1	indeterminate	impassable	impassable
GWJ194-7.4	1	indeterminate	indeterminate	impassable
GWJ361-0.45	1	indeterminate	impassable	impassable
GWJ361-1.7	1	indeterminate	impassable	impassable
GWJ361-1.9	1	indeterminate	impassable	impassable
GWJ129-2.9	1	indeterminate	impassable	impassable
GWJ129-3.1	1	impassable	impassable	impassable

Table A5. Description of crossings surveyed on the George Washington-Jefferson National Forest, summer 2006. Shape abbreviations: C= circular, PA= pipe arch, OBA= open bottom arch, and F= ford. Channel width is the mean bankfull channel width. N= no natural substrate, N (discontin)= discontinuous substrate, Y= continuous natural substrate. An NA (not applicable) indicates outlet drop (no outlet pool or tailwater control) or outlet perch (stream dry) could not be calculated. Negative outlet drop or perch values indicate a submerged outlet (structure partially backwatered). Residual inlet depth values ≥ 0.0 indicate the structure is fully backwatered.

Site ID	Pipe #	Shape	Pipe Condition	Mean Channel Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width: Channel Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
GWJ258-0.2	1	C	poor	12.6	N (discontin)	5.30	0.40	1.68	0.96	0.00	43.4	230.0
GWJ258-3.4	1	PA	poor	16.9	N	5.45	0.41	15.36	11.88	0.00	35.6	194.0
GWJ258-3.4	2	PA	poor	16.9	N	5.08	0.41	15.96	12.84	0.00	35.4	180.0
GWJ226-0.1	1	PA	fair	10.2	N (discontin)	2.13	0.43	-2.88	0.48	0.00	24.0	51.0
GWJ226-0.1	2	PA	fair	10.2	N	3.70	0.43	-0.48	1.56	0.00	25.4	94.0
GWJ125-1.2	1	PA	fair	7.4	N (discontin)	6.88	0.45	26.34	25.14	0.00	33.0	227.0
GWJ125-1.5	1	PA	good	8.0	N	4.44	0.44	5.76	3.12	0.00	29.5	131.0
GWJ125-4.8	1	PA	good	10.9	N (discontin)	1.76	0.64	-2.77	-5.29	0.00	37.0	65.0
GWJ125-5.0	1	PA	fair	9.3	N	5.00	0.53	23.64	22.44	0.00	32.5	162.5
GWJ125-5.8	1	PA	poor	10.7	N	4.92	0.47	6.24	4.38	0.00	32.5	160.0
GWJ125-6.4	1	PA	poor	11.2	N (discontin)	3.38	0.45	-0.24	1.02	0.00	33.0	111.5
GWJ125-7.2	1	C	fair	8.7	N	7.41	0.34	16.92	5.16	0.00	35.2	261.0
GWJ125-7.4	1	C	poor	9.7	N (discontin)	5.10	0.41	12.48	11.28	0.00	34.8	177.5
GWJ125-7.6	1	PA	poor	9.8	N (discontin)	4.99	0.46	18.66	16.74	0.00	36.4	181.5
GWJ125-7.9	1	PA	good	9.8	N	4.77	0.51	10.92	9.24	0.00	40.5	193.0
GWJ125-8.1	1	C	fair	5.6	N	8.34	0.36	5.76	4.86	0.00	30.7	256.0
GWJ125-8.2	1	C	good	6.1	N	6.45	0.49	16.74	13.68	0.00	34.1	220.0
GWJ125-8.4	1	PA	fair	7.5	N	5.47	0.53	5.88	6.78	0.00	30.6	167.5
GWJ361A-0.1	1	C	fair	5.4	N	2.02	0.65	1.92	-0.24	0.00	29.9	60.5
GWJ125-0.2	1	PA	fair	5.0	N	9.69	0.89	28.92	NA	0.00	36.0	349.0
GWJ125-1.0	1	PA	good	9.3	N	6.65	0.68	7.92	6.72	0.00	45.4	302.0
GWJ125-1.1	1	C	good	7.7	N	3.80	0.52	27.30	9.00	0.00	40.1	152.5
GWJ125-1.4	1	PA	fair	9.8	N (discontin)	3.82	0.56	13.32	9.66	0.00	36.7	140.2

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Site ID	Pipe #	Shape	Pipe Condition	Mean Channel Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width: Channel Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
GWJ125-2.2	1	PA	poor	9.3	N (discontin)	5.62	0.62	30.96	27.66	0.00	45.2	254.0
GWJ125-3.2	1	PA	fair	9.1	N	4.09	0.66	22.62	21.30	0.00	36.7	150.0
GWJ125-4.0	1	PA	fair	11.0	N	3.83	0.50	19.08	19.26	0.00	36.6	140.0
GWJ125-4.4	1	PA	good	4.4	N	6.02	0.61	NA	13.26	0.00	28.9	174.0
GWJ125-5.9	1	PA	fair	21.9	N (discontin)	4.33	0.62	-6.66	-9.78	0.00	40.3	174.5
GWJ337-3.5	1	PA	fair	7.2	N	7.55	0.69	16.68	16.62	0.00	38.7	292.0
GWJ1144-2.0	1	PA	fair	5.5	N	2.85	0.96	NA	8.04	0.00	31.2	89.0
GWJ364-1.4	1	PA	good	8.6	N (discontin)	4.13	0.73	9.36	6.84	0.00	34.9	144.0
GWJ364-1.6	1	PA	good	5.7	N	4.91	0.78	18.84	14.88	0.00	27.1	133.0
GWJ1901-2.9	1	PA	good	8.5	N	10.27	0.64	18.06	15.78	0.00	42.3	434.5
GWJ194-1.1	1	C	good	5.1	N	4.48	0.78	8.04	6.36	0.00	48.2	216.0
GWJ194-1.7	1	C	good	5.4	N (discontin)	1.81	0.75	9.12	2.88	0.00	44.3	80.0
GWJ194-2.7	1	PA	poor	6.3	N	3.19	0.78	14.52	13.32	0.00	37.9	121.0
GWJ194-3.0	1	PA	fair	10.9	N	5.78	0.54	10.56	6.60	0.00	49.0	283.0
GWJ194-3.9	1	PA	fair	11.1	N	2.51	0.62	NA	-2.88	0.00	35.9	90.0
GWJ194-3.9	2	PA	fair	11.1	Y	3.10	0.59	-0.60	-1.32	0.00	34.8	108.0
GWJ194-5.0	1	PA	good	9.6	N	5.25	0.48	13.56	10.08	0.00	38.5	202.0
GWJ194-5.1	1	C	good	6.6	N	6.97	0.61	24.96	23.28	0.00	42.2	294.0
GWJ194-5.7	1	C	fair	6.4	N	5.28	0.62	21.84	20.40	0.00	44.3	234.0
GWJ194-7.4	1	PA	fair	6.8	N	3.41	0.56	6.00	0.48	0.00	49.8	170.0
GWJ361-0.45	1	PA	fair	12.8	N	1.83	0.44	19.56	16.98	0.00	33.9	62.0
GWJ361-1.7	1	C	poor	5.8	N	4.67	0.61	10.74	10.80	0.00	31.4	146.5
GWJ361-1.9	1	C	poor	6.2	N	5.82	0.49	13.80	0.00	0.00	46.6	271.0
GWJ129-2.9	1	PA	fair	12.1	N	3.83	0.66	13.92	26.76	0.00	44.4	170.0
GWJ129-3.1	1	C	poor	8.5	N	7.20	0.70	29.28	34.08	0.00	56.8	409.0

Appendix B: Results for the Cherokee National Forest

We completed surveys at 59 (48%) of 122 documented crossing structures on the Ocoee/Hiwassee, Tellico/Hiwassee, Nolichucky/Unaka, and Watagua Ranger Districts in 2006 (Figure B1, Tables B1 and B2). Filter A (strong swimmers and leapers) classified 25% (n=15) of crossings as impassable, 24% (n=14) as passable, and 51% (n=30) as indeterminate (Figure B2, Table B2). Filter B (moderate swimmers and leapers) classified 80% (n=47) of crossings as impassable, 5% (n=3) as passable, and 15% (n=9) as indeterminate (Figure B3, Table B2). Filter C (weak swimmers and leapers) classified 90% (n=53) of crossings as impassable, 5% (n=3) as passable, and 5% (n=3) as indeterminate (Figure B4, Table B2). Characteristics and filter classifications for each crossing are presented in Tables B3-B5.

The majority of the crossings surveyed were circular culverts (85%, n=50) while pipe arches (12%, n=7), open bottom arches (1.5%, n=1), box culverts (1.5%, n=1), vented fords (0%, n=0), and fords (0%, n=0) were less frequently encountered or not encountered. Filter A classified 30% of circular culverts and 0% of pipe arches, open bottom arches and box culverts as impassable (Figure B5). Filter B classified 84% of circular culverts, 57% of pipe arches, and 100% of box culverts as impassable (Figure B6). Filter C classified 92% of circular culverts, 86% of pipe arches, and 100% of box culverts as impassable (Figure B7). The mean crossings width to channel width ratio (excluding fords and multiple structure crossings) was 0.43 ± 0.17 (mean ± SD) (n=41), and only one crossing was greater than or equal to the mean bankfull channel width (Figure B8). The mean crossing width to channel width ratio for surveyed crossings classified impassable by Filter A was 0.40 ± 0.15 (n=15). The mean ratio for crossings classified impassable by Filter B was 0.41 ± 0.15 (n=35), and was 0.41 ± 0.15 (n=37) for Filter C (Figure B9). The mean crossing width to channel width ratio for crossings classified passable by Filter A was 0.60 ± 0.25 (n=5). The mean ratio for crossings classified passable by Filter B was 0.81 ± 0.31 (n=2), and was 0.81 ± 0.31 (n=2) for Filter C (Figure B9).

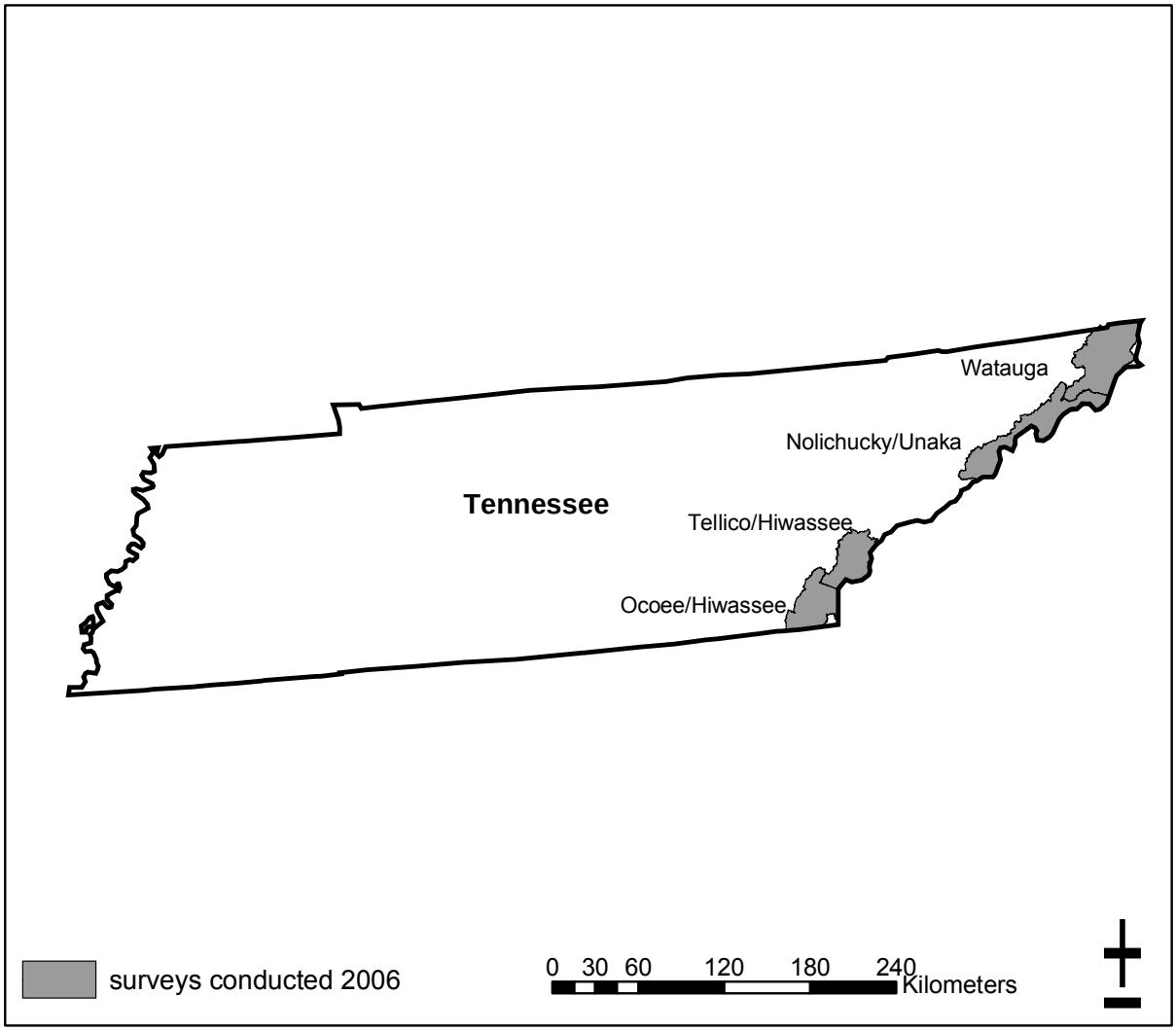

Figure B1. Ranger Districts on the Cherokee National Forest where road-stream crossing surveys were conducted, summer 2006.

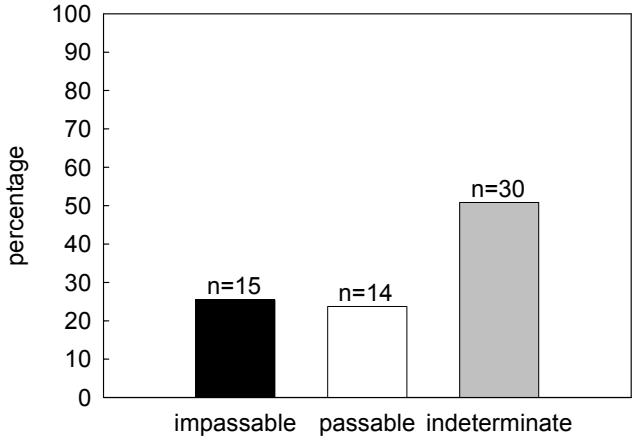

Figure B2. Percentage of crossings classified as impassable, passable, or indeterminate by Filter A; Cherokee National Forest, summer 2006 (N=59).

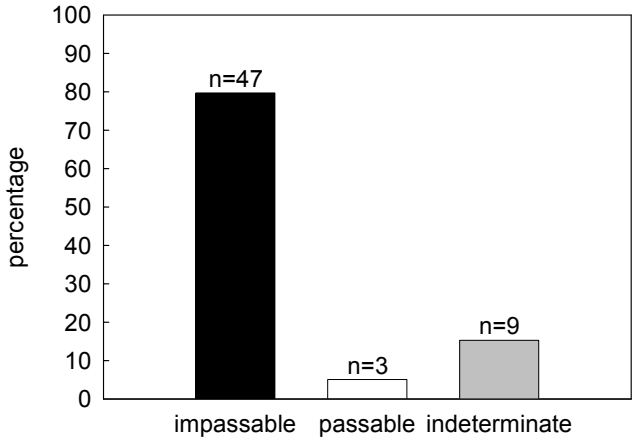

Figure B3. Percentage of crossings classified as impassable, passable, or indeterminate by Filter B; Cherokee National Forest, summer 2006 (N=59).

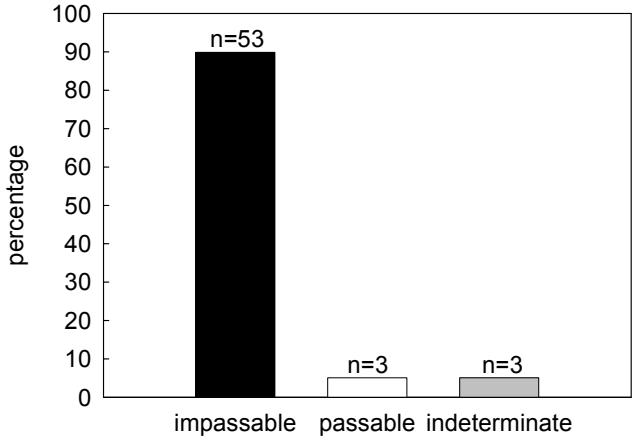

Figure B4. Percentage of crossings classified as impassable, passable, or indeterminate by Filter C; Cherokee National Forest, summer 2006 (N=59).

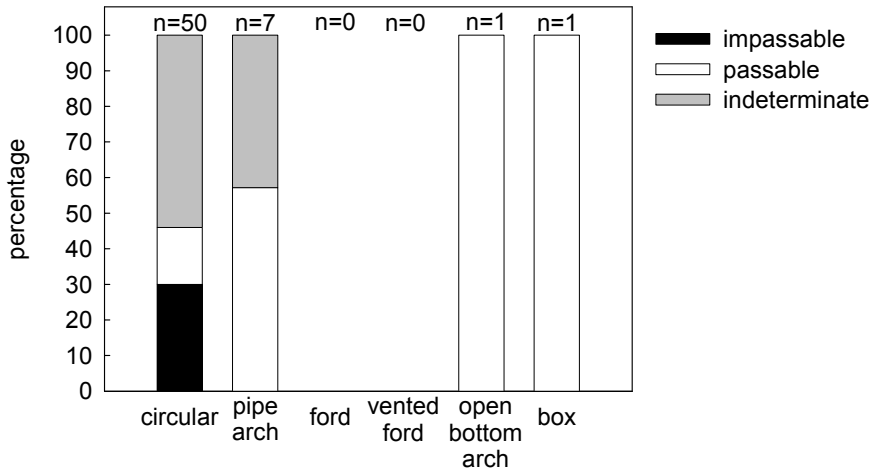

Figure B5. Percentage of each crossing type classified as impassable, passable, or indeterminate for Filter A; Cherokee National Forest, summer 2006 (N=59).

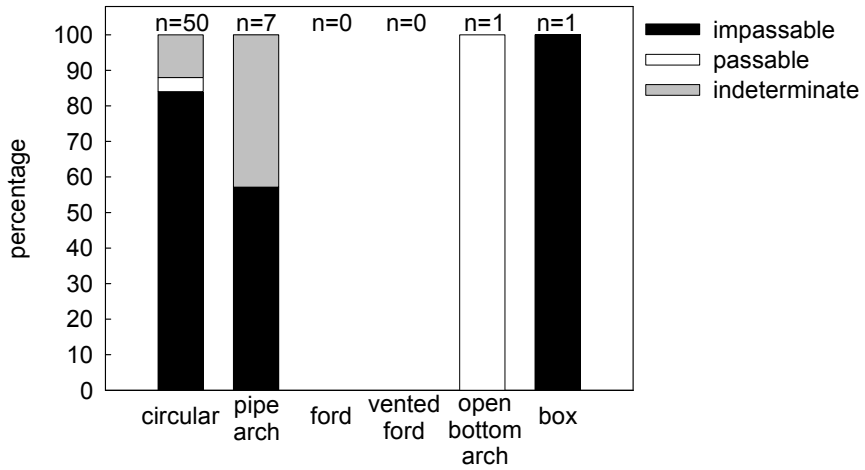

Figure B6. Percentage of each crossing type classified as impassable, passable, or indeterminate for Filter B; Cherokee National Forest, summer 2006 (N=59).

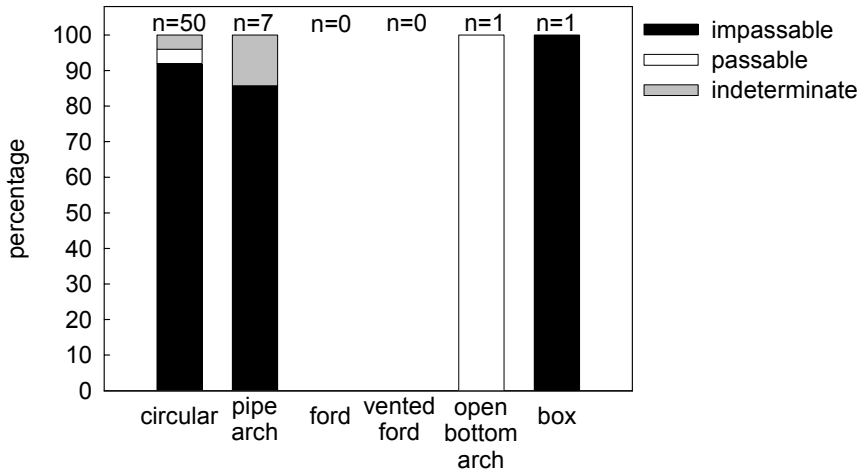

Figure B7. Percentage of each crossing type classified as impassable, passable, or indeterminate for Filter C; Cherokee National Forest, summer 2006 (N=59).

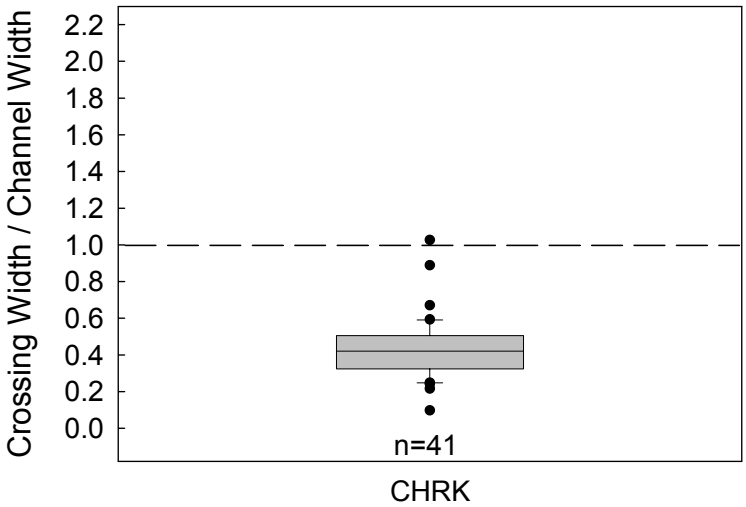

Figure B8. Crossing width to bankfull channel width ratio for crossings surveyed in summer 2006 on the Cherokee National Forest (excluding fords, vented fords and multiple structure crossings). A ratio of 1.0 (dashed line) or greater indicates the crossing structure opening is greater than or equal to the bankfull channel width. The top and bottom of the boxes represent the 25th and 75th percentiles, the bar in the center of each box represents the median, whiskers represent the 10th and 90th percentiles, and closed circles represent the entire range of the data.

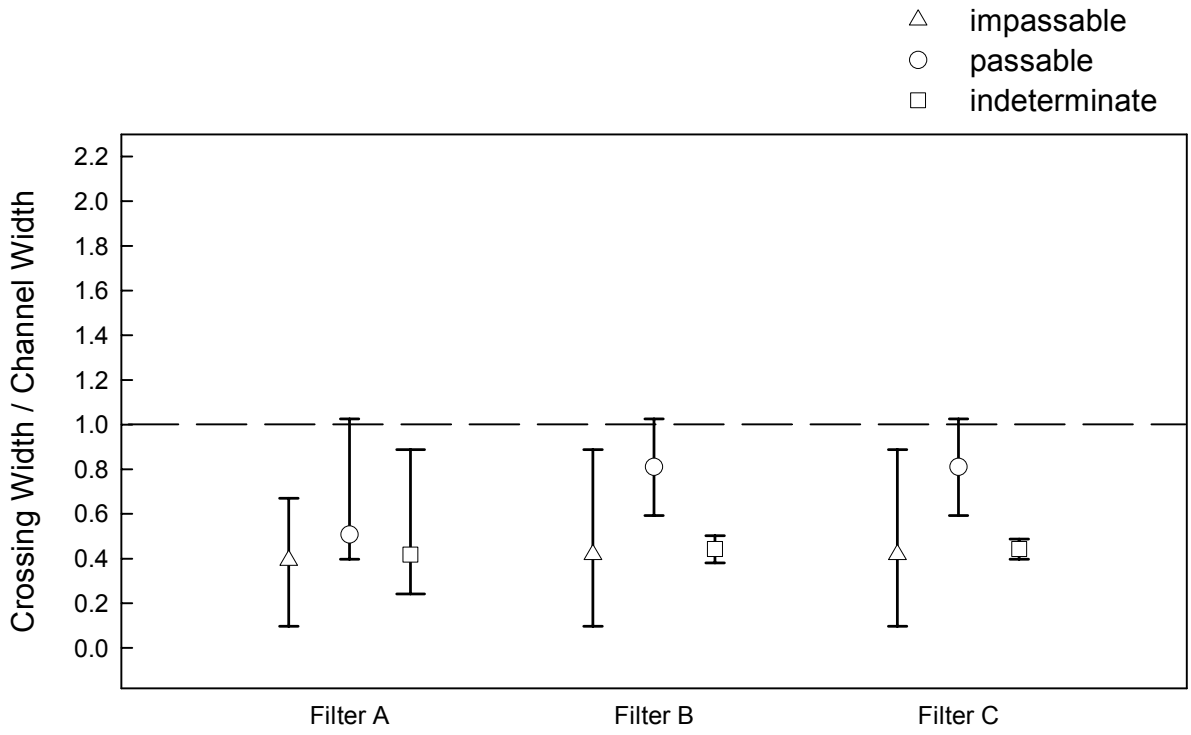

Figure A9. Crossing width to bankfull channel width ratio for crossings classified as impassable, passable, or indeterminate in summer 2006 on the Cherokee National Forest (excluding fords, vented fords, and multiple structure crossings). A ratio of 1.0 (dashed line) or greater indicates the crossing structure opening is greater than or equal to the bankfull channel width. The symbol inside each set of whiskers represents the median, and the top and bottom of the whiskers represent the maximum and minimum values.

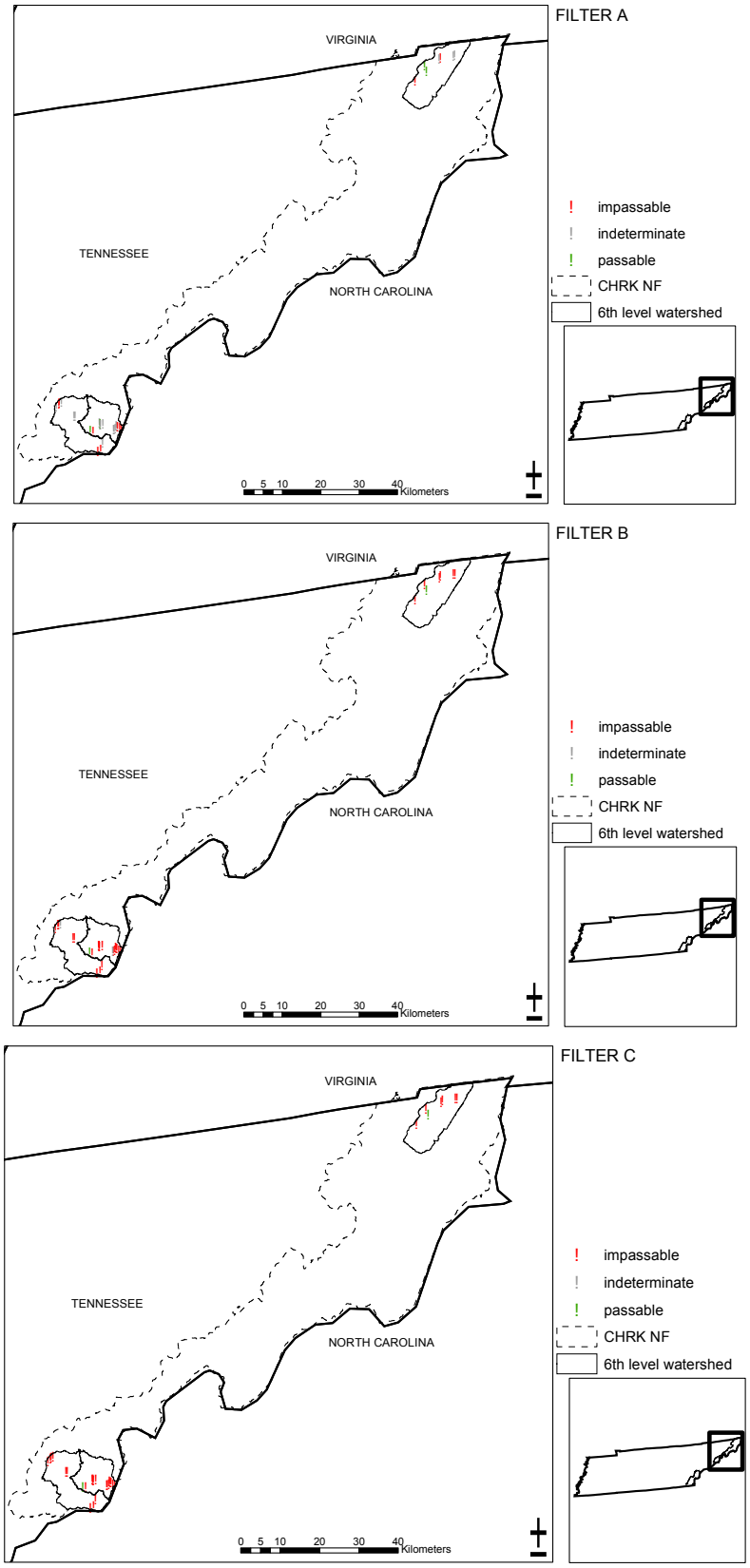

Figure B10. Location of crossings classified for fish passage by coarse filters A, B, and C within 6th level watersheds on the northern portion of the Cherokee National Forest, summer 2006.

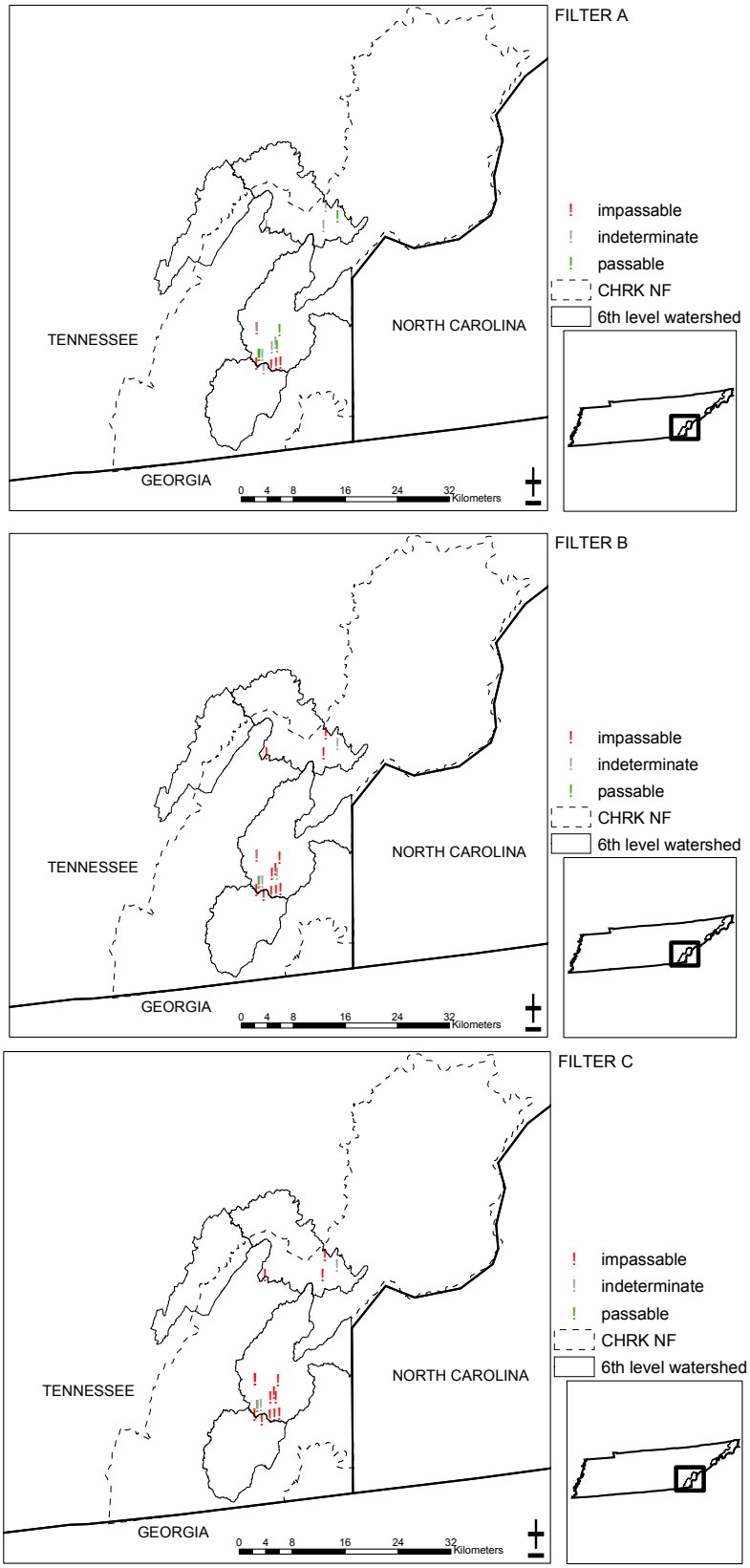

Figure B11. Location of crossings classified for fish passage by coarse filters A, B, and C within 6th level watersheds on the southern portion of the Cherokee National Forest, summer 2006.

Table B1. Number of crossings documented (Total crossings documented) and not surveyed (Crossings not surveyed) on the Cherokee National Forest in summer 2006. Reasons for not surveying a documented site include: no suitable fish habitat upstream of crossing (NH); no access to site due to closed roads or private gates (NA); crossing was a natural ford (NF); crossing was a bridge (BR).

Forest	Total crossings documented	Crossings not surveyed (n, [%])				
		NH	NA	NF	BR	Total not surveyed
CHRKNF	122	42 (67)	0 (0)	16 (25)	5 (8)	63 (52)

Table B2. Number of crossings surveyed (Total surveyed) with coarse filter results for the Cherokee National Forest in summer 2006. Coarse filter results are presented for Filter A, Filter B, and Filter C (see filter descriptions, Fig 3 – 5).

Forest	Total surveyed	Coarse filter results								
		Impassable (n, [%])			Passable (n, [%])			Indeterminate (n, [%])		
		A	B	C	A	B	C	A	B	C
CHRKNF	59	15 (25)	47 (80)	53 (90)	14 (24)	3 (5)	3 (5)	30 (51)	9 (15)	3 (5)

Table B3. Location of crossings surveyed on the Cherokee National Forest during the summer of 2006. Site ID consists of the Forest abbreviation (CHNF), road the crossing is on (300), and the distance (miles) from the junction road (0.8).

Site ID	# of Pipes	District	Junction Road	Stream Name	Quad	6th level watershed
CHNF300-0.8	1	Watauga	133	Tank Hollow	Laurel Bloomery	060101020104
CHNF300-1.0	1	Watauga	133	UT Tank Hollow	Laurel Bloomery	060101020104
CHNF60802-0.1	1	Watauga	69	Heaberlin Branch	Shady Valley	060101020104
CHNF60804-0.2	1	Watauga	34	Low Gap Branch	Shady Valley	060101020104
CHNF60833-0.2	1	Watauga	6083	UT Beaverdam Creek	Laurel Bloomery	060101020104
CHNF60833-0.7	1	Watauga	6083	Dark Hollow	Laurel Bloomery	060101020104
CHNF69B-0.8	2	Watauga	69	Marshall Branch	Shady Valley	060101020104
CHNF107-0.3	1	Nolichucky-Unaka	1182	UT Lemon Prong	Lemon Gap	060101050801
CHNF107-0.7	1	Nolichucky-Unaka	1182	UT Lemon Prong	Lemon Gap	060101050801
CHNF107-1.4	1	Nolichucky-Unaka	1182	Shelton Branch	Lemon Gap	060101050801
CHNF107-1.8	2	Nolichucky-Unaka	1182	Rattlesnake Branch	Lemon Gap	060101050801
CHNF209-0.6	1	Nolichucky-Unaka	209	Spicewood Branch	Waterville	060101050801
CHNF209-1.0	1	Nolichucky-Unaka	209	UT Spicewood Branch	Waterville	060101050801
CHNF209-1.1	1	Nolichucky-Unaka	209	UT Spicewood Branch	Waterville	060101050801
CHNF209-1.2	1	Nolichucky-Unaka	209	UT Spicewood Branch	Waterville	060101050801
CHNF22441-1.0	1	Nolichucky-Unaka	209	UT Hunter Creek	Waterville	060101050801
CHNF22441-2.1	2	Nolichucky-Unaka	209	Hunter Creek	Waterville	060101050801
CHNF3249-0.1	2	Nolichucky-Unaka	gate	UT Big Creek	Lemon Gap	060101050801
CHNF3249-0.1-1	2	Nolichucky-Unaka	107	UT Big Creek	Lemon Gap	060101050801
CHNF3249-0.2	2	Nolichucky-Unaka	gate	Big Creek	Lemon Gap	060101050801
CHNF96-0.2	1	Nolichucky-Unaka	107	Shelton Branch	Lemon Gap	060101050801
CHNFbluemill-0.4	1	Nolichucky-Unaka	22421	UT Big Creek	Lemon Gap	060101050801
CHNF2251012-0.9	1	Nolichucky-Unaka	2251-4	UT Middle Prong Gulf Cr	Waterville	060101050802
CHNF225102-1.1	1	Nolichucky-Unaka	2251-3	Gap Creek	Waterville	060101050802
CHNF2251-4-0.5	1	Nolichucky-Unaka	2251-3	UT Bearpen Branch	Waterville	060101050802
CHNF402-1.6	1	Nolichucky-Unaka	702	UT Carney Branch	Neddy Mountain	060101050802
CHNF403-0.5	1	Nolichucky-Unaka	402	UT Deer Hill Branch	Neddy Mountain	060101050802
CHNF403-0.6	1	Nolichucky-Unaka	402	Deer Hill Branch	Neddy Mountain	060101050802
CHNF403-1.7	1	Nolichucky-Unaka	402	Fine Trail Branch	Neddy Mountain	060101050802
CHNF5141a-1.0	1	Nolichucky-Unaka	5141	Piney Branch	Waterville	060101050802

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Site ID	# of Pipes	District	Junction Road	Stream Name	Quad	6th level watershed
CHNF5141a-1.5	1	Nolichucky-Unaka	5141	Pauldo Branch	Waterville	060101050802
CHNF103-7.2	1	Ocoee-Hiwassee	30	Mary Branch	McFarland	060200020301
CHNF103-7.5	1	Ocoee-Hiwassee	30	Mary Branch	McFarland	060200020301
CHNF1176-1-2.6	1	Ocoee-Hiwassee	23	UT Rymer Camp Branch	Ducktown	060200020301
CHNF1176-1-3.5	1	Ocoee-Hiwassee	23	UT Rymer Camp Branch	Ducktown	060200020301
CHNF1176-4.3	1	Ocoee-Hiwassee	23	Rymer Camp Branch	Ducktown	060200020301
CHNF23-0.1	1	Ocoee-Hiwassee	80	Bearpen Branch	McFarland	060200020301
CHNF23-0.6	4	Ocoee-Hiwassee	80	Big Lost Creek	McFarland	060200020301
CHNF23-1.3	1	Ocoee-Hiwassee	68	Piney Flats Branch	Ducktown	060200020301
CHNF23-1.4	2	Ocoee-Hiwassee	68	Standing Rock Branch	Ducktown	060200020301
CHNF23-1.7	1	Ocoee-Hiwassee	68	Puncheon Camp Branch	Ducktown	060200020301
CHNF23-2.5	1	Ocoee-Hiwassee	103	UT Piney Flats Branch	McFarland	060200020301
CHNF23-6.5	1	Ocoee-Hiwassee	68	Smith Creek	McFarland	060200020301
CHNF68-11.2	1	Ocoee-Hiwassee	68	Piney Flats Branch	Ducktown	060200020301
CHNF341-2.1	1	Tellico-Hiwassee	68	UT Conasauga Creek	Tellico Plains	060200020401
CHNF341-4.6	1	Tellico-Hiwassee	68	UT Conasauga Creek	Tellico Plains	060200020401
CHNF603-1.6	1	Tellico-Hiwassee	68	Hooper Branch	Tellico Plains	060200020401
CHNF652-1.0	1	Ocoee-Hiwassee	653	UT Dry Creek	Mecca	060200020401
CHNF33172-1.7	1	Ocoee-Hiwassee	68	UT Gassaway Creek	Ducktown	060200030207

Table B4. Coarse filter A, B, and C, classifications for crossings surveyed on the Cherokee National Forest, summer 2006.

Site ID	Pipe #	Filter A	Filter B	Filter C
CHNF300-0.8	1	indeterminate	impassable	impassable
CHNF300-1.0	1	indeterminate	impassable	impassable
CHNF60802-0.1	1	passable	passable	passable
CHNF60804-0.2	1	impassable	impassable	impassable
CHNF60833-0.2	1	indeterminate	impassable	impassable
CHNF60833-0.7	1	impassable	impassable	impassable
CHNF69B-0.8	1	passable	impassable	impassable
CHNF69B-0.8	2	passable	impassable	impassable
CHNF107-0.3	1	impassable	impassable	impassable
CHNF107-0.7	1	impassable	impassable	impassable
CHNF107-1.4	1	indeterminate	impassable	impassable
CHNF107-1.8	1	indeterminate	impassable	impassable
CHNF107-1.8	2	indeterminate	impassable	impassable
CHNF209-0.6	1	indeterminate	impassable	impassable
CHNF209-1.0	1	passable	impassable	impassable
CHNF209-1.1	1	indeterminate	impassable	impassable
CHNF209-1.2	1	indeterminate	impassable	impassable
CHNF22441-1.0	1	impassable	impassable	impassable
CHNF22441-2.1	1	passable	passable	passable
CHNF22441-2.1	2	indeterminate	impassable	impassable
CHNF3249-0.1	1	indeterminate	impassable	impassable
CHNF3249-0.1	2	indeterminate	impassable	impassable
CHNF3249-0.1-1	1	indeterminate	impassable	impassable
CHNF3249-0.1-1	2	indeterminate	impassable	impassable
CHNF3249-0.2	1	indeterminate	indeterminate	impassable
CHNF3249-0.2	2	indeterminate	indeterminate	impassable
CHNF96-0.2	1	impassable	impassable	impassable
CHNFbluemill-0.4	1	indeterminate	impassable	impassable
CHNF2251012-0.9	1	indeterminate	impassable	impassable
CHNF225102-1.1	1	impassable	impassable	impassable
CHNF2251-4-0.5	1	impassable	impassable	impassable
CHNF402-1.6	1	indeterminate	indeterminate	impassable
CHNF403-0.5	1	impassable	impassable	impassable
CHNF403-0.6	1	impassable	impassable	impassable
CHNF403-1.7	1	indeterminate	impassable	impassable
CHNF5141a-1.0	1	indeterminate	impassable	impassable
CHNF5141a-1.5	1	indeterminate	impassable	impassable
CHNF103-7.2	1	impassable	impassable	impassable
CHNF103-7.5	1	indeterminate	indeterminate	impassable
CHNF1176-1-2.6	1	impassable	impassable	impassable
CHNF1176-1-3.5	1	impassable	impassable	impassable
CHNF1176-4.3	1	impassable	impassable	impassable
CHNF23-0.1	1	indeterminate	impassable	impassable
CHNF23-0.6	1	passable	impassable	impassable
CHNF23-0.6	2	passable	indeterminate	impassable

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Site ID	Pipe #	Filter A	Filter B	Filter C
CHNF23-0.6	3	passable	impassable	impassable
CHNF23-0.6	4	passable	impassable	impassable
CHNF23-1.3	1	passable	passable	passable
CHNF23-1.4	1	passable	indeterminate	impassable
CHNF23-1.4	2	passable	indeterminate	indeterminate
CHNF23-1.7	1	indeterminate	indeterminate	indeterminate
CHNF23-2.5	1	indeterminate	impassable	impassable
CHNF23-6.5	1	passable	impassable	impassable
CHNF68-11.2	1	impassable	impassable	impassable
CHNF341-2.1	1	indeterminate	impassable	impassable
CHNF341-4.6	1	indeterminate	impassable	impassable
CHNF603-1.6	1	passable	indeterminate	indeterminate
CHNF652-1.0	1	indeterminate	impassable	impassable
CHNF33172-1.7	1	indeterminate	impassable	impassable

Table B5. Description of crossings surveyed on Cherokee National Forest, summer 2006. Shape abbreviations: C= circular, PA= pipe arch, OBA= open bottom arch, and F= ford. Channel width is the mean bankfull channel width. N= no natural substrate, N (discontin)= discontinuous substrate, Y= continuous natural substrate. An NA (not applicable) indicates outlet drop (no outlet pool or tailwater control) or outlet perch (stream dry) could not be calculated. Negative outlet drop or perch values indicate a submerged outlet (structure partially backwatered). Residual inlet depth values ≥ 0.0 indicate the structure is fully backwatered.

Site ID	Pipe #	Shape	Pipe Condition	Mean Channel Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width: Channel Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%)* Length (ft)
CHNF300-0.8	1	C	fair	15.0	N	5.83	0.53	15.84	13.80	0.00	61.2	357.0
CHNF300-1.0	1	C	fair	11.3	N	6.59	0.40	18.00	16.32	0.00	34.6	228.0
CHNF60802-0.1	1	C	good	11.8	Y	1.19	0.59	3.12	-3.72	0.00	44.4	53.0
CHNF60804-0.2	1	C	poor	6.0	N	7.75	0.33	5.04	3.96	0.00	20.2	156.5
CHNF60833-0.2	1	C	good	11.8	N	4.05	0.42	18.60	18.36	0.00	42.7	173.0
CHNF60833-0.7	1	C	fair	14.7	N	5.71	0.34	37.68	34.32	0.00	40.6	232.0
CHNF69B-0.8	1	C	good	9.9	N	1.28	0.30	14.40	12.96	0.00	30.5	39.0
CHNF69B-0.8	2	C	good	9.9	N	1.26	0.30	15.00	12.48	0.00	34.9	44.0
CHNF107-0.3	1	C	poor	7.0	N (discontin)	9.81	0.43	4.50	2.76	0.00	23.5	230.5
CHNF107-0.7	1	C	fair	9.2	N (discontin)	10.41	0.22	NA	1.56	0.00	27.0	281.0
CHNF107-1.4	1	C	fair	7.9	N (discontin)	4.92	0.25	17.82	6.00	0.00	31.0	152.5
CHNF107-1.8	1	C	fair	9.1	N	4.33	0.22	2.70	1.50	0.00	20.9	90.5
CHNF107-1.8	2	C	fair	9.1	N	3.94	0.22	5.76	2.22	0.00	20.7	81.5
CHNF209-0.6	1	C	good	9.0	N	3.77	0.33	-4.44	-6.78	0.00	20.7	78.0
CHNF209-1.0	1	C	good	6.1	N	1.26	0.49	10.08	8.04	0.00	20.6	26.0
CHNF209-1.1	1	C	good	6.4	N	4.47	0.47	2.52	-0.24	0.00	20.8	93.0
CHNF209-1.2	1	C	good	6.4	N	3.87	0.47	14.28	12.36	0.00	20.8	80.5
CHNF22441-1.0	1	C	fair	6.0	N	11.06	0.67	NA	6.00	0.00	34.0	376.0
CHNF22441-2.1	1	C	good	7.8	Y	3.28	0.45	7.80	2.64	0.00	35.1	115.0
CHNF22441-2.1	2	C	good	7.8	N	5.58	0.51	4.32	2.76	0.00	34.4	192.0
CHNF3249-0.1	1	C	good	7.9	N	6.10	0.51	15.66	11.58	0.00	34.7	211.5
CHNF3249-0.1	2	C	good	7.9	N	4.99	0.51	19.68	5.52	0.00	34.7	173.0
CHNF3249-0.1-1	1	C	fair	11.9	N	6.28	0.42	NA	12.60	0.00	29.3	184.0
CHNF3249-0.1-1	2	C	fair	11.9	N	3.85	0.42	NA	9.48	0.00	31.0	119.5
CHNF3249-0.2	1	C	good	14.0	N	2.31	0.54	8.88	4.86	0.00	40.3	93.0
CHNF3249-0.2	2	C	good	14.0	N	2.37	0.54	7.20	6.84	0.00	40.3	95.5

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Site ID	Pipe #	Shape	Pipe Condition	Mean Channel Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width: Channel Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
CHNF96-0.2	1	C	good	6.9	N	8.55	0.58	NA	16.92	0.00	40.6	347.0
CHNFbluemill-0.4	1	C	good	8.3	N	4.71	0.24	1.44	0.12	0.00	20.8	98.0
CHNF2251012-0.9	1	C	fair	8.0	N	5.85	0.25	3.72	2.28	0.00	41.0	240.0
CHNF225102-1.1	1	C	fair	5.2	N	13.45	0.10	-0.48	-0.90	0.00	40.0	538.0
CHNF2251-4-0.5	1	C	fair	4.2	N	12.78	0.36	15.60	14.64	0.00	38.0	485.5
CHNF402-1.6	1	C	poor	5.3	N	2.85	0.38	4.56	4.68	0.00	30.2	86.0
CHNF403-0.5	1	C	fair	4.8	N	7.37	0.31	16.44	15.36	0.00	26.2	193.0
CHNF403-0.6	1	C	fair	4.0	N	8.85	0.25	18.36	12.36	0.00	39.0	345.0
CHNF403-1.7	1	C	fair	3.6	N	5.46	0.42	3.12	3.24	0.00	25.1	137.0
CHNF5141a-1.0	1	C	fair	9.6	N	2.49	0.42	23.52	22.56	0.00	46.5	116.0
CHNF5141a-1.5	1	C	fair	11.5	N	2.33	0.48	10.68	8.88	0.00	49.3	115.0
CHNF103-7.2	1	C	good	19.0	N	2.63	0.42	25.68	11.76	0.00	97.8	257.0
CHNF103-7.5	1	PA	good	18.5	N (discontin)	1.79	0.50	6.36	4.80	0.00	82.8	148.0
CHNF1176-1-2.6	1	C	poor	8.6	N	7.06	0.58	13.98	12.24	0.00	50.6	357.0
CHNF1176-1-3.5	1	C	fair	6.5	N	12.48	0.54	34.20	30.84	0.00	42.6	531.5
CHNF1176-4.3	1	C	good	9.1	N	11.44	0.49	44.52	46.44	0.00	46.6	533.0
CHNF23-0.1	1	C	fair	8.1	N	6.00	0.31	10.20	7.68	0.00	32.5	195.0
CHNF23-0.6	1	PA	good	30.4	N	1.40	0.18	12.84	11.04	0.00	21.4	30.0
CHNF23-0.6	2	PA	good	30.4	N	1.40	0.18	9.48	8.04	0.00	21.4	30.0
CHNF23-0.6	3	PA	good	30.4	N	1.32	0.18	10.20	9.00	0.00	20.5	27.0
CHNF23-0.6	4	PA	good	30.4	N	1.07	0.18	18.36	13.08	0.00	20.5	22.0
CHNF23-1.3	1	OBA	good	11.4	Y	1.52	1.03	-5.16	-6.06	8.16	16.5	25.0
CHNF23-1.4	1	C	fair	8.2	N	2.27	0.18	4.08	3.06	0.00	20.0	45.5
CHNF23-1.4	2	C	fair	8.2	N	2.22	0.18	3.78	2.76	0.00	20.0	44.5
CHNF23-1.7	1	PA	good	10.3	N	2.25	0.49	NA	1.02	0.00	32.5	73.0
CHNF23-2.5	1	PA	fair	4.6	N	4.20	0.89	10.44	8.52	0.00	34.5	145.0
CHNF23-6.5	1	B	good	19.7	N	0.85	0.51	15.24	11.16	0.00	28.2	24.0
CHNF68-11.2	1	C	fair	6.4	N	9.94	0.39	NA	13.14	0.00	41.0	407.5
CHNF341-2.1	1	C	fair	5.5	N	4.83	0.51	12.78	14.70	0.00	28.7	138.5
CHNF341-4.6	1	C	fair	10.4	N	4.66	0.43	23.04	21.72	0.00	28.3	132.0

table continued next page…

Site ID	Pipe #	Shape	Pipe Condition	Mean Channel Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width: Channel Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
CHNF603-1.6	1	C	good	7.6	N	1.37	0.40	0.60	-1.08	0.00	30.0	41.0
CHNF652-1.0	1	C	fair	5.9	N	3.91	0.26	18.48	16.80	0.00	20.1	78.5
CHNF33172-1.7	1	C	poor	10.0	N (discontin)	6.34	0.30	13.44	11.04	0.00	28.4	180.0

Appendix C: Results for the National Forests in Alabama

We completed surveys at 72 (70%) of 103 documented crossing structures on the Talladega (Talladega and Oakmulgee Ranger Districts), Tuskegee, and Conecuh National Forests in 2006 (Figure C1, Tables C1 and C2). Filter A (strong swimmers and leapers) classified 10% (n=7) of crossings as impassable, 50% (n=36) as passable, and 40% (n=29) as indeterminate (Figure C2, Table C2). Filter B (moderate swimmers and leapers) classified 36% (n=26) of crossings as impassable, 29% (n=21) as passable, and 35% (n=25) as indeterminate (Figure C3, Table C2). Filter C (weak swimmers and leapers) classified 46% (n=33) of crossing as impassable, 21% (n=15) as passable, and 33% (n=24) as indeterminate (Figure C4, Table C2). Characteristics and filter classifications for each crossing are presented in Tables C3-C5.

The majority of the crossings surveyed were circular culverts (49%, n=35), and pipe arches (35%, n=25), while box culverts (12%, n=9), vented fords (4%, n=3), fords (0%, n=0), and open bottom arches (0%, n=0) were less frequently encountered or not encountered. Filter A classified 6% of circular culverts and 16% of pipe arches as impassable (Figure C5). Filter B classified 37% of circular culverts, and 48% of pipe arches as impassable (Figure C6). Filter C classified 43% of circular culverts, 52% of pipe arches, and 100% of vented fords as impassable (Figure C7). The mean crossing width to channel width ratio (excluding fords, vented fords, and multiple structure crossings) was 0.78 ± 0.30 (mean ± SD) (n=29), and 7 crossings were greater than or equal to the bankfull channel width (Figure C8). The mean crossing width to channel width ratio for surveyed crossings classified impassable by Filter A was 0.76 ± 0.13 (n=3). The mean ratio for crossings classified impassable by Filter B was 0.80 ± 0.23 (n=7), and was 0.70 ± 0.28 (n=10) for Filter C (Figure C9). The mean crossing width to channel width ratio for surveyed crossings classified passable by Filter A was 0.87 ± 0.32 (n=18). The mean ratio for crossings classified passable by Filter B was 0.93 ± 0.35 (n=10), and was 0.95 ± 0.29 (n=8) for Filter C (Figure C9).

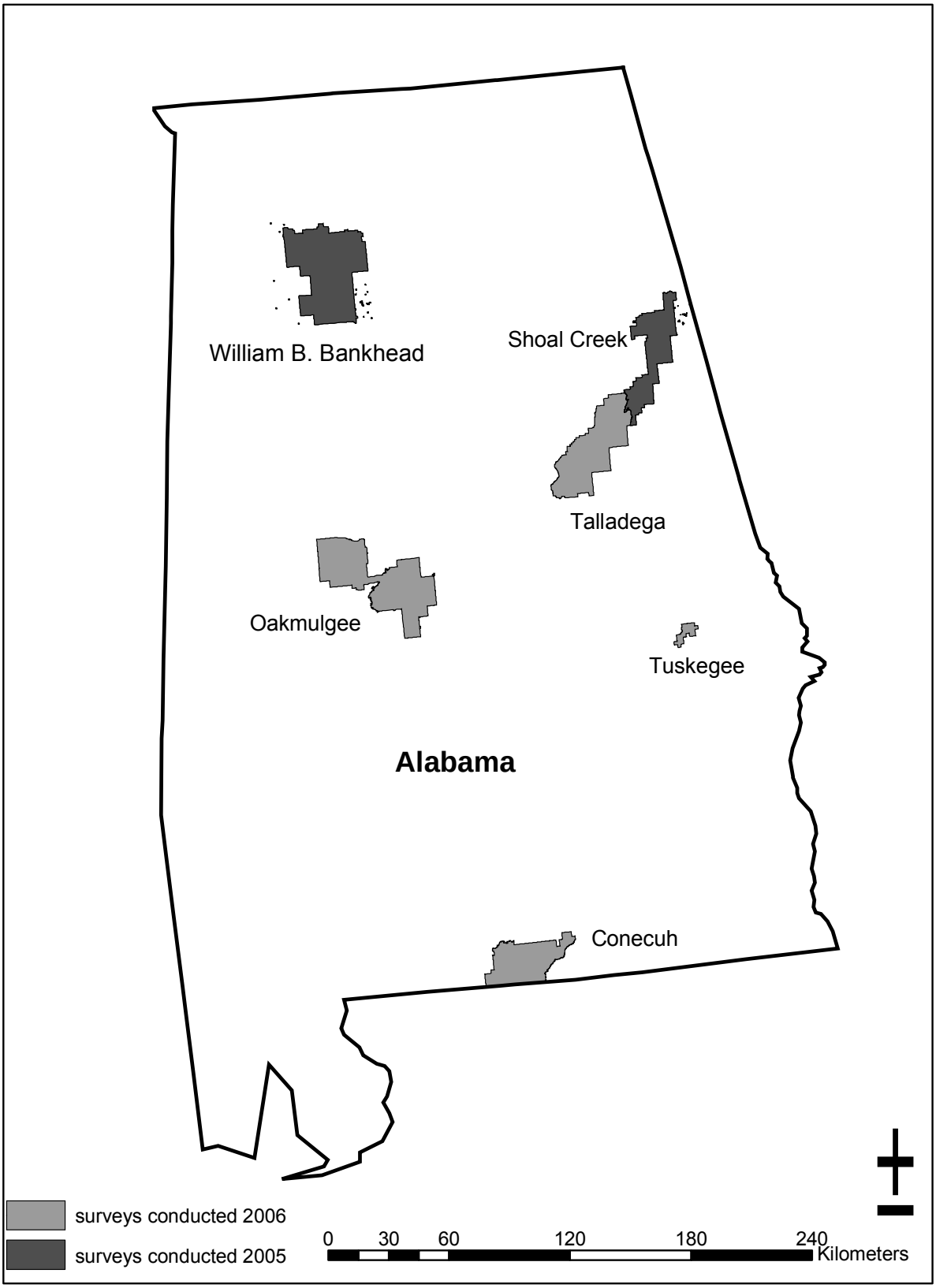

Figure C1. Ranger Districts on the National Forests in Alabama where road-stream crossing surveys were conducted, in 2005 and 2006. Results from 2005 surveys are presented in Coffman et al. 2005.

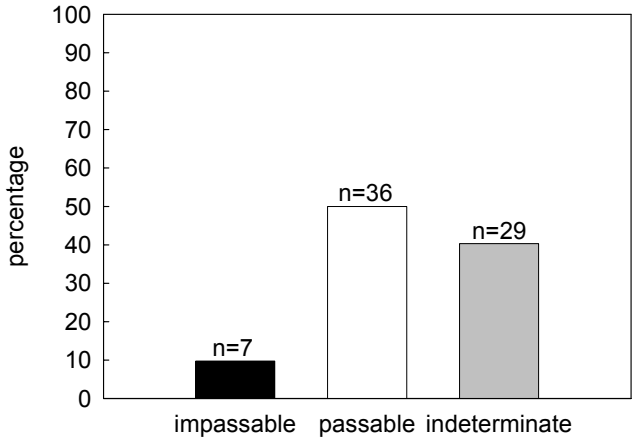

Figure C2. Percentage of crossings classified as impassable, passable, or indeterminate for Filter A; National Forests in Alabama, summer 2006 (N=72).

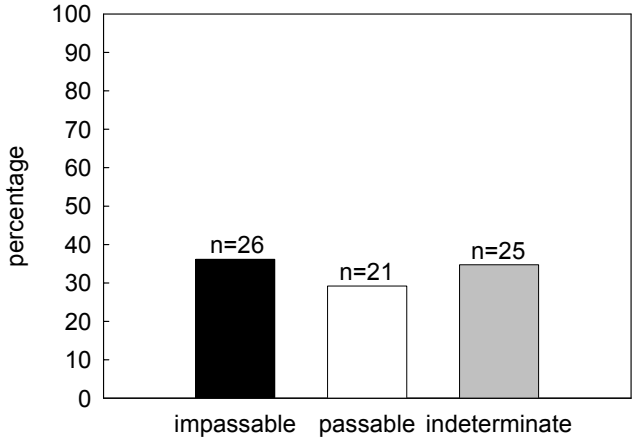

Figure C3. Percentage of crossings classified as impassable, passable, or indeterminate for Filter B; National Forests in Alabama, summer 2006 (N=72).

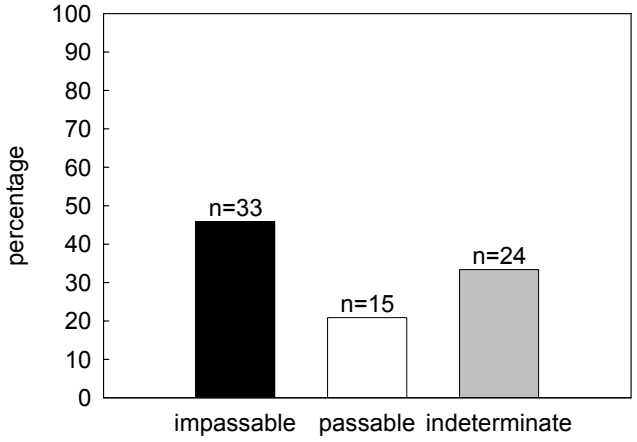

Figure C4. Percentage of crossings classified as impassable, passable, or indeterminate for Filter C; National Forests in Alabama, summer 2006 (N=72).

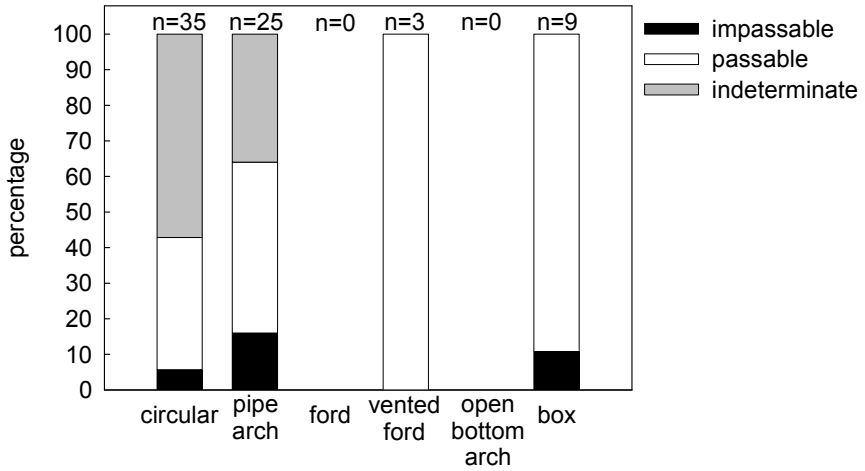

Figure C5. Percentage of each crossing type classified as impassable, passable, or indeterminate for Filter A; National Forests in Alabama, summer 2006 (N=72).

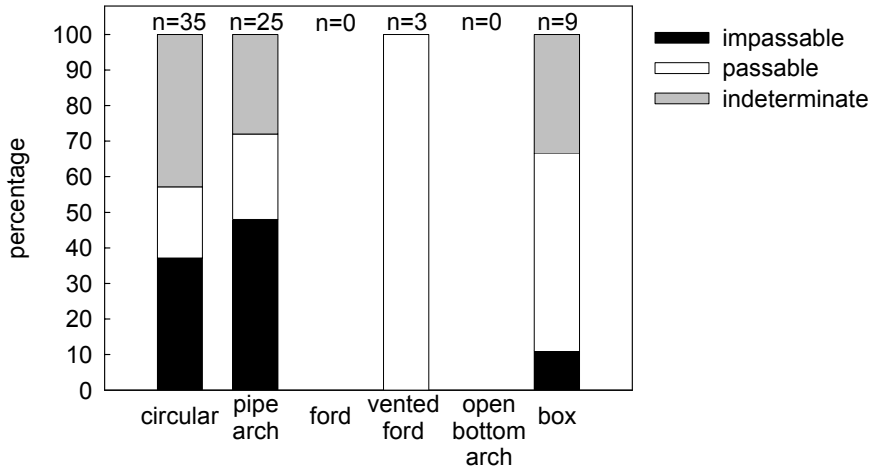

Figure C6. Percentage of each crossing type classified as impassable, passable, or indeterminate for Filter B; National Forests in Alabama, summer 2006 (N=72).

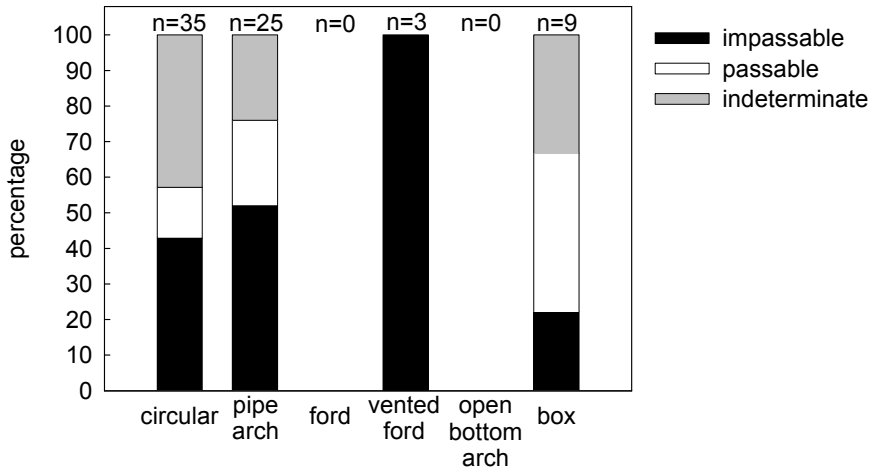

Figure C7. Percentage of each crossing type classified as impassable, passable, or indeterminate for Filter C; National Forests in Alabama, summer 2006 (N=72).

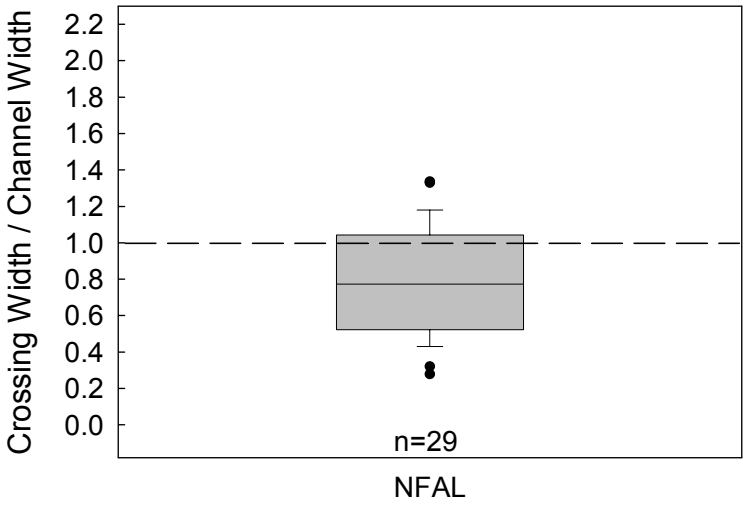

Figure C8. Crossing width to bankfull channel width ratio for crossings surveyed in summer 2006 on the National Forests in Alabama (excluding fords, vented fords, and multiple structure crossings). A ratio of 1.0 (dashed line) or greater indicates the crossing structure opening is greater than or equal to the bankfull channel width. The top and bottom of the boxes represent the 25th and 75th percentiles, the bar in the center of each box represents the median, whiskers represent the 10th and 90th percentiles, and closed circles represent the entire range of the data.

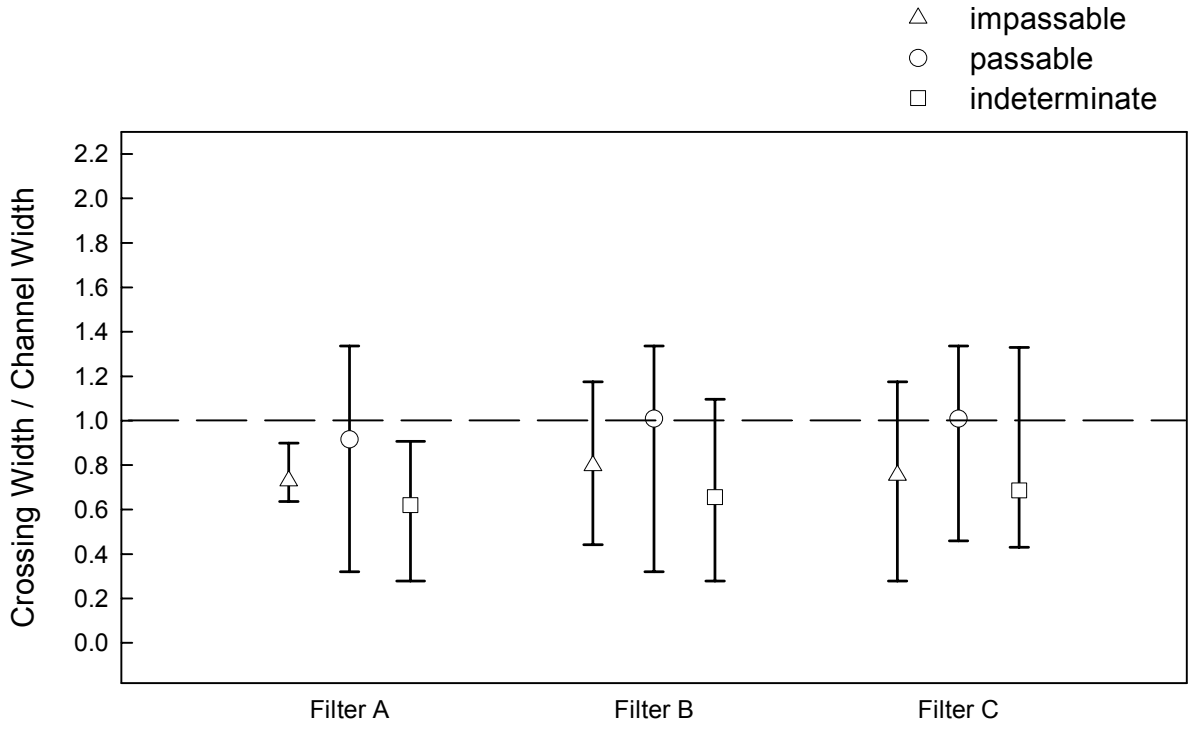

Figure C9. Crossing width to bankfull channel width ratio for crossings classified as impassable, passable, or indeterminate in summer 2006 on the National Forests in Alabama (excluding fords, vented fords, and multiple structure crossings). A ratio of 1.0 (dashed line) or greater indicates the crossing structure opening is greater than or equal to the bankfull channel width. The symbol inside each set of whiskers represents the median, and the top and bottom of the whiskers represent the maximum and minimum values.

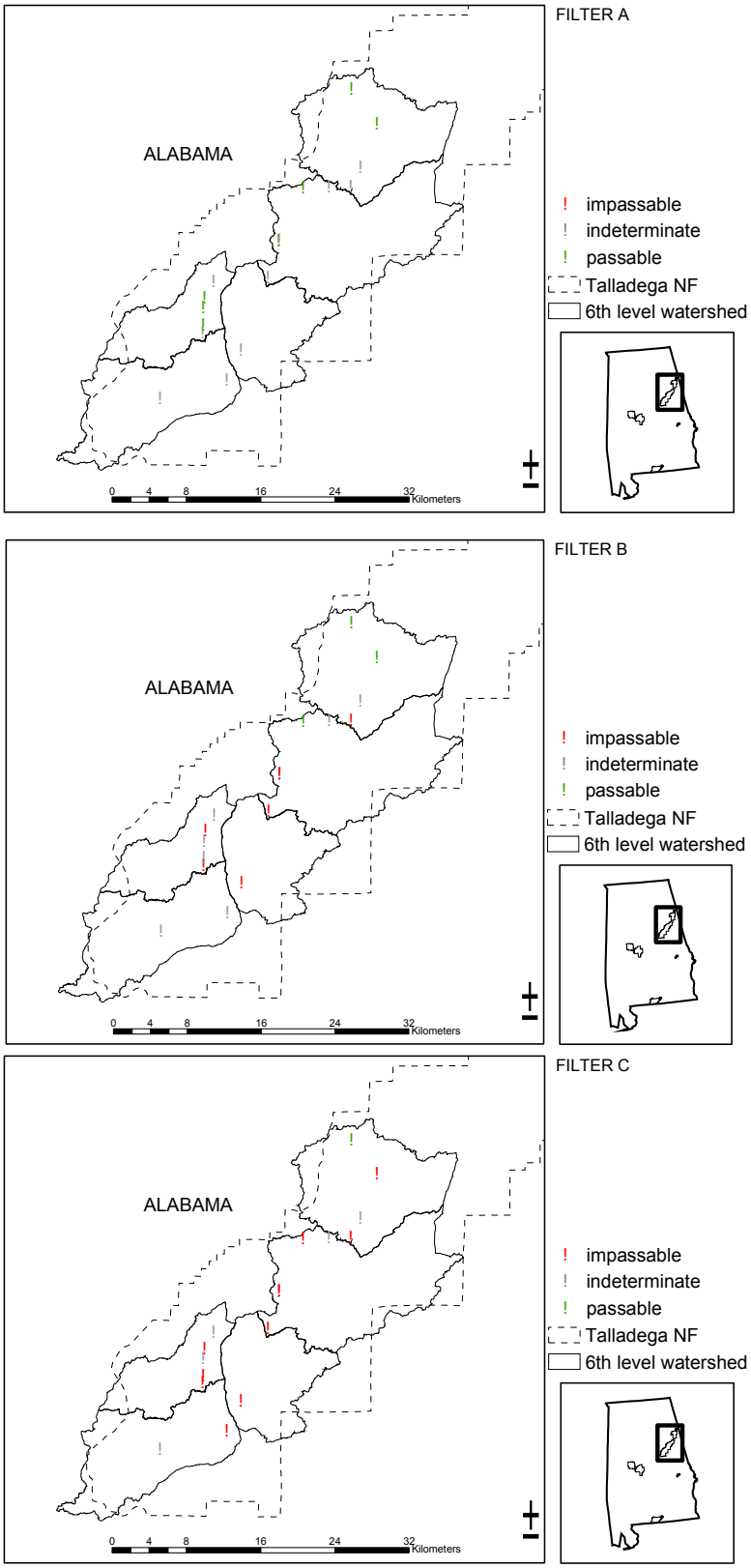

Figure C10. Location of crossings classified for fish passage by coarse filters A, B, and C within 6th level watersheds, on the Talladega National Forest Talladega Ranger District, summer 2006.

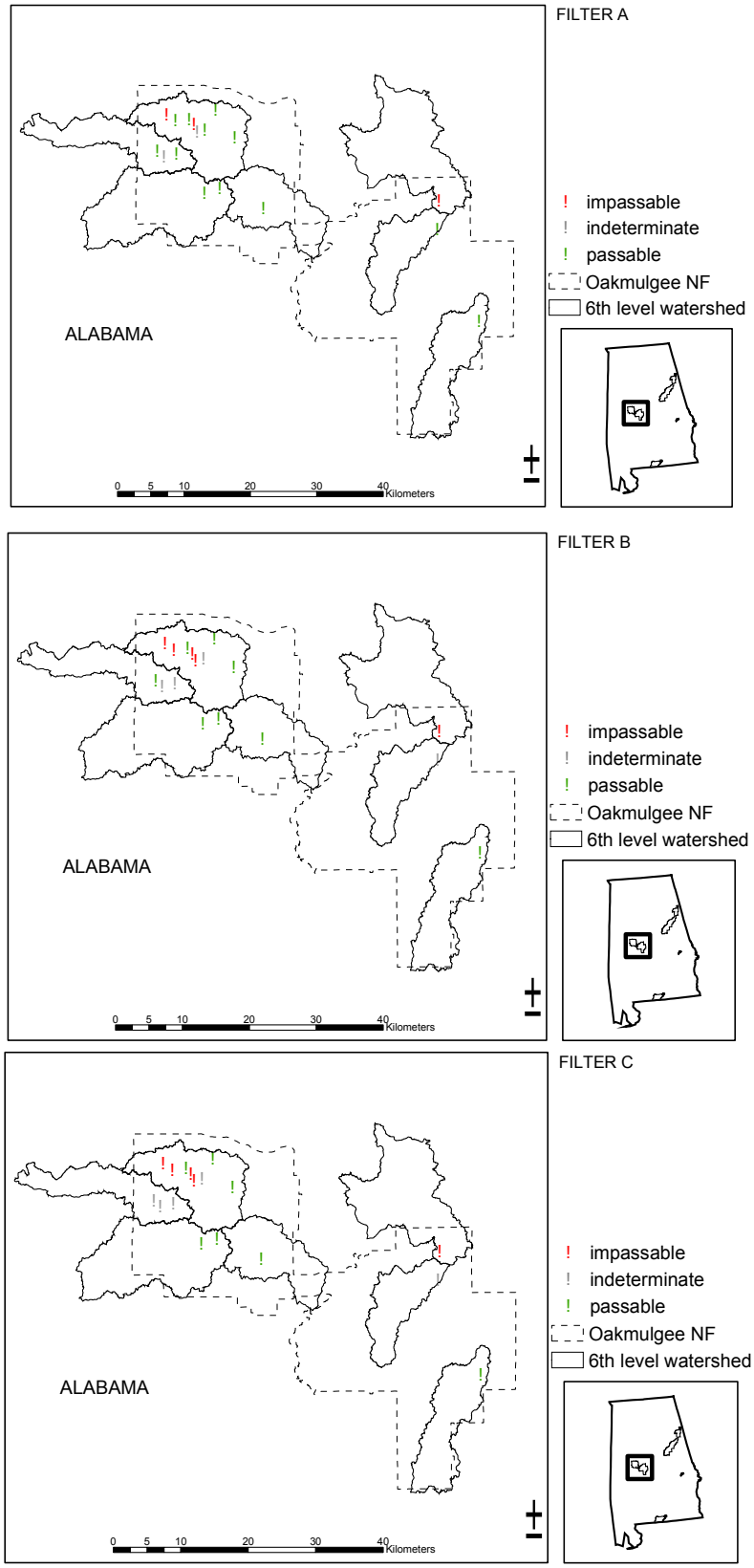

Figure C11. Location of crossings classified for fish passage by coarse filters A, B, and C within 6th level watersheds, on the Talladega National Forest Oakmulgee Ranger District, summer 2006.

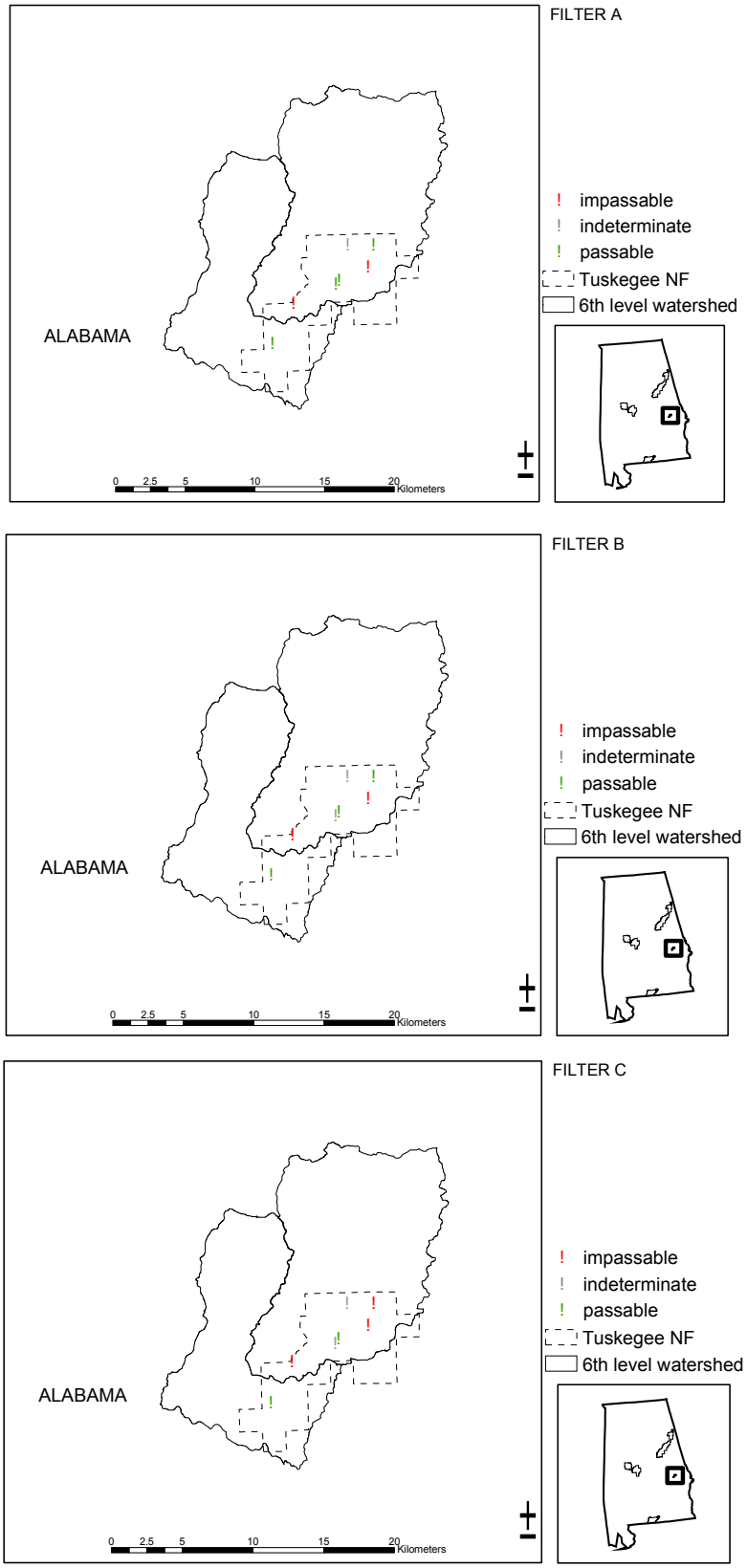

Figure C12. Location of crossings classified for fish passage by coarse filters A, B, and C within 6th level watersheds, on the Tuskegee National Forest, summer 2006.

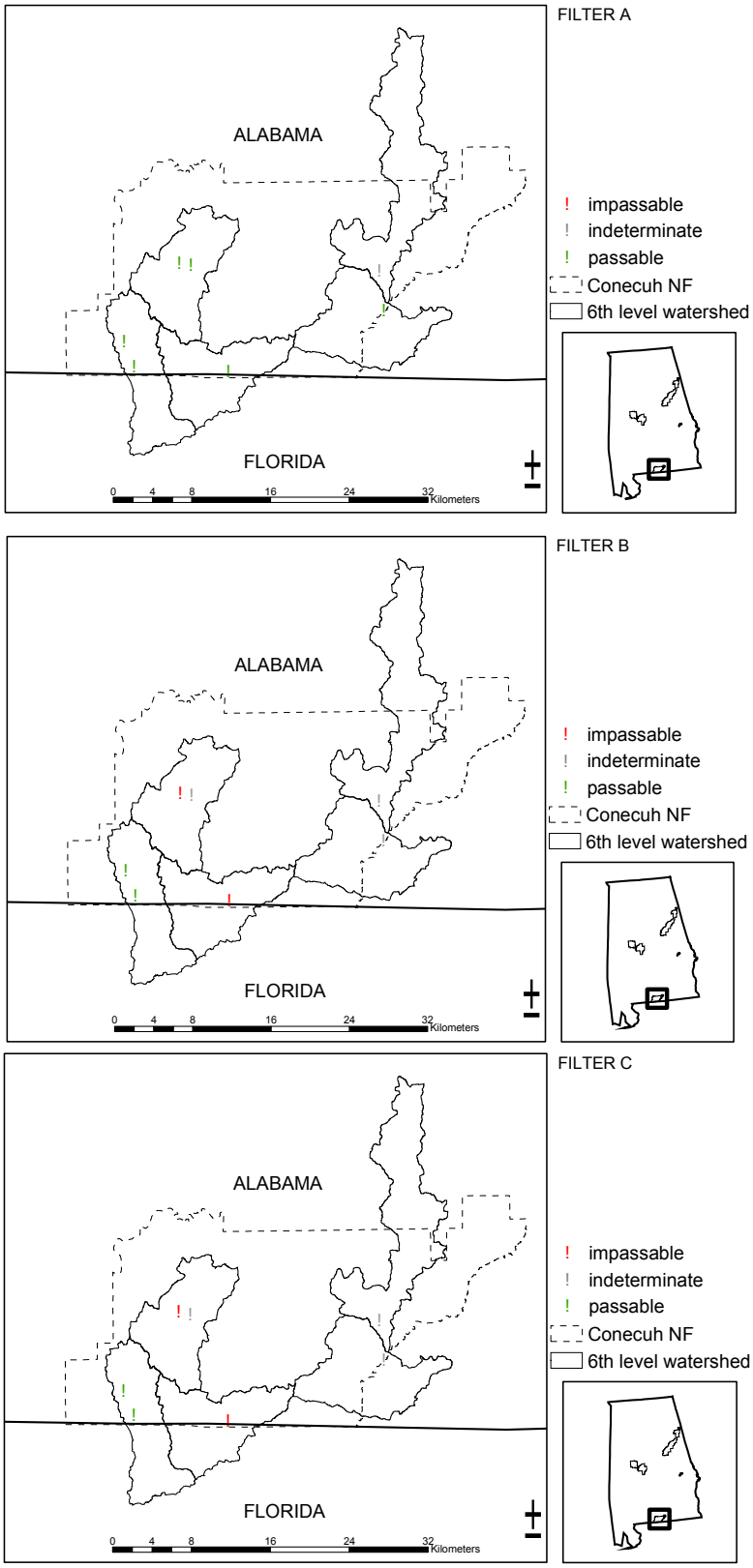

Figure C13. Location of crossings classified for fish passage by coarse filters A, B, and C within 6th level watersheds, on the Conecuh National Forest, summer 2006.

Table C1. Number of crossings documented (Total crossing documented) and not surveyed (Crossings not surveyed) on the National Forests in Alabama (Talladega, Tuskegee, and Conecuh NFs) in summer 2006. Reasons for not surveying a documented site include: no suitable fish habitat upstream of crossing (NH); no access to site due to closed roads or private gates (NA); crossing was a natural ford (NF); crossing was a bridge (BR).

Forest	Total crossings documented	Crossings not surveyed (n, [%])				
		NH	NA	NF	BR	Total not surveyed
NFAL	103	14 (45)	0 (0)	0 (0)	17 (55)	31 (30)

Table C2. Number of crossings surveyed (Total surveyed) with coarse filter results for the National Forests in Alabama (Talladega, Tuskegee, and Conecuh NFs) in summer 2006. Coarse filter results are presented for Filter A, Filter B, and Filter C (see filter descriptions, Fig 3 – 5).

Forest	Total surveyed	Coarse filter results								
		Impassable (n, [%])			Passable (n, [%])			Indeterminate (n, [%])		
		A	B	C	A	B	C	A	B	C
NFAL	72	7 (10)	26 (36)	33 (46)	36 (50)	21 (29)	15 (21)	29 (40)	25 (35)	24 (33)

Table C3. Location of crossings surveyed on the National Forests in Alabama during the summer of 2006. Site ID consists of the Forest abbreviation (CNF), road the crossing is on (337), and the distance (miles) from the junction road (1.1).

Site ID	# of Pipes	Forest #	District	Junction Road	Stream Name	Quad	6th Level Watershed
CNF337-1.1	1	5	Conecuh	24	Pond Creek	Wing	031401030303
CNF337-3.8	1	6	Conecuh	24	Tributary of the Yellow River	Wing	031401030401
CONF305-2.3	2	4	Conecuh	11	Wolf Pit Branch	Bradley	031401040102
CONF305-3.0	2	3	Conecuh	11	Bear Branch	Bradley	031401040102
CONF374-0.6	1	8	Conecuh	180	UT Boggy Hollow Creek	Bradley	031401040104
CONF346b-0.6	1	--	Conecuh	38	UT Rock Creek	Parker Springs	031401040106
CONF346b-1.4	2	9	Conecuh	11	Wagon Body Branch	Parker Springs	031401040106
TANF637-0.5	1	20	Talladega	103	Horse Creek	Ironaton	031501060608
TANF637-2.2	3	21	Talladega	103	Fayne Creek	Ironaton	031501060608
TNF385-1.5	3	42	Talladega	105	Tater Creek	Ironaton	031501060608
TNF637-3.2	3	28	Talladega	385	Cheaha Creek	Ironaton	031501060608
TANF308-0.9	2	45	Talladega	77	UT Blue Creek	Porter Gap	031501060701
TANF699-0.6	1	22	Talladega	77	Shepherd Branch	Porter Gap	031501060701
TANF699-0.8	1	31	Talladega	77	UT Shepherd Branch	Porter Gap	031501060701
TNF103-1.8	1	43	Talladega	310	Mump Creek	Ironaton	031501060701
TNF310-1.2	1	41	Talladega	103	UT Mump Creek	Ironaton	031501060701
TANF616-0.6	1	39	Talladega	607	UT Tallasseehatchee Creek	Bulls Gap	031501070201
TNF601-3.1	3	23	Talladega	148	UT Tallasseehatchee Creek	Sylacauga East	031501070201
TANF615-4.0	2	19	Talladega	607	Swept Creek	Porter Gap	031501070202
TNF615-1.1	2	26	Talladega	615L	UT Swept Creek	Porter Gap	031501070202
TNF615-2.9	3	25	Talladega	615L	UT Emanhee Creek	Porter Gap	031501070202
TNF615-3.6	2	24	Talladega	615L	UT Emanhee Creek	Porter Gap	031501070202
TNFcr-0.6	2	40	Talladega	615	Smelley Creek	Porter Gap	031501070202
TANF662A-0.7	2	29	Talladega	7	UT Hatchet Creek	Bulls Gap	031501070801
TKNF905-0.1	1	49	Tuskegee	906	UT Choctafaula Creek	Little Texas	031501100401

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Site ID	Pipe #	Forest #	District	Junction Road	Stream Name	Quad	6th Level Watershed
TKNF905-0.3	1	50	Tuskegee	906	UT Choctafaula Creek	Little Texas	031501100401
TKNF910-0.9	3	54	Tuskegee	54	Hodnett Creek	Loachapoka	031501100401
TKNF916-0.7	2	57	Tuskegee	908	UT Choctafaula Creek	Little Texas	031501100401
TUNF900-0.9	1	48	Tuskegee	913	UT Choctafaula Creek	Tuskegee	031501100401
TUNFcr54-1.0	1	58	Tuskegee	915	UT Choctafaula Creek	Loachapoka	031501100401
TUNF937-0.1	1	56	Tuskegee	29	UT Uphapee Creek	Tuskegee	031501100402
ONF29/35-1.5	1	73	Oakmulgee	82	Little Creek	Centreville East	031502020503
ONFyaeger-.001	3	78	Oakmulgee	44	Miller Branch	Pondville	031502020506
ONF35-0.2	1	76	Oakmulgee	19	UT Beaverdam Creek	Oakmulgee	031502020801
ONF421-1.9	1	59	Oakmulgee	426	Little Oakmulgee Creek	Plantersville	031502020804
TANF707-1.8	1	--	Oakmulgee	731	UT Elliots Creek	Payne Lake	031601130202
TANF707-2.5	1	62	Oakmulgee	731	UT South Sandy Creek	Payne Lake	031601130202
TANF707-4.5	1	61	Oakmulgee	731	UT South Sandy Creek	Duncanville	031601130202
TANF707-5.6	2	60	Oakmulgee	731	UT South Sandy Creek	Duncanville	031601130202
TANF726-0.4	1	67	Oakmulgee	721	UT Wiggins Creek	Duncanville	031601130202
TANF731-1.2	1	69	Oakmulgee	726	UT Ragland Branch	Pondville	031601130202
TANF751-2.0	1	70	Oakmulgee	726	UT Wiggins Creek	Payne Lake	031601130202
TANF751-3.5	1	72	Oakmulgee	726	UT South Sandy Creek	Duncanville	031601130202
TANF50-0.6	1	74	Oakmulgee	49	UT Elliots Creek	Payne Lake	031601130301
TANF50-2.6	1	75	Oakmulgee	49	UT Elliots Creek	Payne Lake	031601130301
TANF708-0.2	1	63	Oakmulgee	50	UT Elliots Creek	Payne Lake	031601130301
TANF715-1.6	1	66	Oakmulgee	726	UT Fivemile Creek	Payne Lake	031601130401
TANF726-0.7	2	68	Oakmulgee	25	UT Fivemile Creek	Payne Lake	031601130401

Table C4. Coarse filters A, B, and C, classifications for surveyed crossings on the National Forests in Alabama, summer 2006.

Site ID	Pipe #	Forest #	Filter A	Filter B	Filter C
CNF337-1.1	1	5	indeterminate	indeterminate	indeterminate
CNF337-3.8	1	6	passable	indeterminate	indeterminate
CONF305-2.3	1	4	indeterminate	impassable	impassable
CONF305-2.3	2	4	indeterminate	impassable	impassable
CONF305-3.0	1	3	indeterminate	indeterminate	indeterminate
CONF305-3.0	2	3	indeterminate	indeterminate	indeterminate
CONF374-0.6	1	8	passable	impassable	impassable
CONF346b-0.6	1	--	passable	passable	passable
CONF346b-1.4	1	9	passable	passable	passable
CONF346b-1.4	2	9	passable	indeterminate	indeterminate
TANF637-0.5	1	20	indeterminate	indeterminate	indeterminate
TANF637-2.2	1	21	indeterminate	impassable	impassable
TANF637-2.2	2	21	indeterminate	impassable	impassable
TANF637-2.2	3	21	indeterminate	impassable	impassable
TNF385-1.5	1	42	passable	passable	passable
TNF385-1.5	2	42	passable	passable	passable
TNF385-1.5	3	42	passable	passable	passable
TNF637-3.2	1	28	passable	passable	impassable
TNF637-3.2	2	28	passable	passable	impassable
TNF637-3.2	3	28	passable	passable	impassable
TANF308-0.9	1	45	indeterminate	impassable	impassable
TANF308-0.9	2	45	indeterminate	impassable	impassable
TANF699-0.6	1	22	passable	indeterminate	indeterminate
TANF699-0.8	1	31	indeterminate	impassable	impassable
TNF103-1.8	1	43	indeterminate	indeterminate	indeterminate
TNF310-1.2	1	41	passable	passable	impassable
TANF616-0.6	1	39	indeterminate	indeterminate	impassable
TNF601-3.1	3	23	indeterminate	indeterminate	indeterminate
TANF615-4.0	1	19	indeterminate	indeterminate	impassable
TANF615-4.0	2	19	passable	impassable	impassable
TNF615-1.1	1	26	indeterminate	impassable	impassable
TNF615-1.1	2	26	indeterminate	impassable	impassable
TNF615-2.9	1	25	passable	indeterminate	indeterminate
TNF615-2.9	2	25	passable	indeterminate	indeterminate
TNF615-2.9	3	25	indeterminate	impassable	impassable
TNF615-3.6	1	24	passable	impassable	impassable
TNF615-3.6	2	24	passable	impassable	impassable
TNFcr-0.6	1	40	indeterminate	indeterminate	indeterminate
TNFcr-0.6	2	40	indeterminate	indeterminate	indeterminate

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Site ID	Pipe #	Forest #	Filter A	Filter B	Filter C
TANF662A-0.7	1	29	indeterminate	impassable	impassable
TANF662A-0.7	2	29	indeterminate	impassable	impassable
TKNF905-0.1	1	49	passable	passable	passable
TKNF905-0.3	1	50	passable	indeterminate	indeterminate
TKNF910-0.9	1	54	indeterminate	indeterminate	indeterminate
TKNF910-0.9	2	54	indeterminate	indeterminate	indeterminate
TKNF910-0.9	3	54	indeterminate	indeterminate	indeterminate
TKNF916-0.7	1	57	impassable	impassable	impassable
TKNF916-0.7	2	57	impassable	impassable	impassable
TUNF900-0.9	1	48	impassable	impassable	impassable
TUNFcr54-1.0	1	58	passable	indeterminate	impassable
TUNF937-0.1	1	56	passable	passable	passable
ONF29/35-1.5	1	73	impassable	impassable	impassable
ONFyaeger-.001	1	78	passable	indeterminate	indeterminate
ONFyaeger-.001	2	78	passable	passable	passable
ONFyaeger-.001	3	78	passable	passable	passable
ONF35-0.2	1	76	indeterminate	indeterminate	indeterminate
ONF421-1.9	1	59	passable	passable	passable
TANF707-1.8	1	--	indeterminate	impassable	impassable
TANF707-2.5	1	62	impassable	impassable	impassable
TANF707-4.5	1	61	passable	impassable	impassable
TANF707-5.6	1	60	impassable	impassable	impassable
TANF707-5.6	2	60	impassable	impassable	impassable
TANF726-0.4	1	67	passable	passable	passable
TANF731-1.2	1	69	passable	passable	passable
TANF751-2.0	1	70	passable	indeterminate	indeterminate
TANF751-3.5	1	72	passable	passable	passable
TANF50-0.6	1	74	passable	indeterminate	indeterminate
TANF50-2.6	1	75	passable	passable	indeterminate
TANF708-0.2	1	63	indeterminate	indeterminate	indeterminate
TANF715-1.6	1	66	passable	passable	passable
TANF726-0.7	1	68	passable	passable	passable
TANF726-0.7	2	68	passable	passable	indeterminate

Table C5. Description of crossings surveyed on the National Forests in Alabama, summer 2006. Shape abbreviations: C= circular, PA= pipe arch, OBA= open bottom arch, V= vented ford, B= box, and F= ford. Channel width is the mean bankfull channel width. N= no natural substrate, N (discontin)= discontinuous substrate, Y= continuous natural substrate. An NA (not applicable) indicates outlet drop (no outlet pool or tailwater control) or outlet perch (stream dry) could not be calculated. Negative outlet drop or perch values indicate a submerged outlet (structure partially backwatered). Residual inlet depth values ≥ 0.0 indicate the structure is fully backwatered.

Site ID	Pipe #	Forest #	Shape	Pipe Condition	Mean Chnl Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width : Chnl Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
CNF337-1.1	1	5	C	fair	11.2	N	2.97	0.49	NA	-28.80	0.00	34.0	101.0
CNF337-3.8	1	6	C	poor	6.9	N	1.06	0.72	NA	1.32	0.00	36.0	38.0
CONF305-2.3	1	4	PA	good	6.0	N	1.83	1.01	14.76	-2.04	0.00	68.7	126.0
CONF305-2.3	2	4	PA	good	6.0	N	1.54	1.01	17.88	-1.56	0.00	64.8	100.0
CONF305-3.0	1	3	PA	fair	NA	N	1.48	NA	NA	-18.36	0.00	53.3	79.0
CONF305-3.0	2	3	PA	fair	NA	N	1.06	NA	NA	-15.96	0.00	53.0	56.0
CONF374-0.6	1	8	PA	fair	6.4	N	0.29	1.17	15.48	14.16	0.00	48.1	14.0
CONF346b-0.6	1	--	PA	fair	4.1	N	0.39	1.10	1.02	-1.32	0.72	37.5	14.5
CONF346b-1.4	1	9	PA	fair	4.8	N	0.95	0.73	-12.6	-10.56	7.92	41.0	39.0
CONF346b-1.4	2	9	PA	fair	4.8	N	0.63	0.73	-0.72	-6.72	0.00	41.0	26.0
TANF637-0.5	1	20	C	good	7.1	N	2.01	0.77	-6.00	-6.84	0.00	54.6	110.0
TANF637-2.2	1	21	C	fair	17.7	N	1.57	0.40	18.48	18.00	0.00	36.4	57.0
TANF637-2.2	2	21	C	fair	17.7	N	1.54	0.40	17.76	15.96	0.00	36.4	56.0
TANF637-2.2	3	21	C	fair	17.7	N	2.06	0.40	17.10	15.00	0.00	36.4	75.0
TNF385-1.5	2	42	B	good	20.8	Y	0.13	0.67	NA	1.92	0.00	39.2	5.0
TNF385-1.5	3	42	B	good	20.8	Y	0.64	0.67	NA	5.52	0.00	41.9	27.0
TNF637-3.2	1	28	VF	good	42.3	N (discontin)	0.57	0.07	8.76	2.40	0.00	44.1	25.0
TNF637-3.2	2	28	VF	good	42.3	N	0.28	0.07	8.64	2.04	0.00	43.1	12.0
TNF637-3.2	3	28	VF	good	42.3	N	0.46	0.07	9.00	0.36	0.00	45.6	21.0
TANF308-0.9	1	45	C	fair	7.0	N	2.83	0.29	20.52	15.06	0.00	39.2	111.0
TANF308-0.9	2	45	C	fair	7.0	N	3.23	0.29	10.44	8.04	0.00	39.2	5.0

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Site ID	Pipe #	Forest #	Shape	Pipe Condition	Mean Chnl Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width : Chnl Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
TANF699-0.6	1	22	B	good	13.5	N	1.15	0.45	-2.76	-3.60	0.00	35.6	41.0
TANF699-0.8	1	31	PA	good	6.4	N	5.39	0.91	-0.84	16.32	0.00	46.6	251.0
TNF103-1.8	1	43	C	good	7.0	N	3.22	0.55	0.24	-1.08	0.00	43.8	141.0
TNF310-1.2	1	41	C	poor	6.2	N (discontin)	0.53	0.32	9.00	7.92	0.00	32.1	17.0
TANF616-0.6	1	39	C	poor	10.8	N	2.99	0.28	-1.80	31.56	0.00	62.2	186.0
TNF601-3.1	3	23	C	fair	6.8	N	2.68	0.37	-2.64	-5.40	0.00	25.0	67.0
TANF615-4.0	1	19	PA	fair	10.6	N	1.46	0.71	7.32	3.24	0.00	42.5	62.0
TANF615-4.0	2	19	PA	fair	10.6	N	0.76	0.71	10.02	6.36	0.00	42.5	32.5
TNF615-1.1	1	26	C	poor	8.0	N	2.06	0.63	13.68	12.36	0.00	36.0	74.0
TNF615-1.1	2	26	C	poor	8.0	N	1.63	0.63	15.24	10.92	0.00	36.3	59.0
TNF615-2.9	1	25	C	poor	11.8	N	2.24	0.25	0.00	-0.48	0.00	14.7	33.0
TNF615-2.9	2	25	C	poor	11.8	N	3.33	0.25	-3.00	-3.48	0.00	14.7	49.0
TNF615-2.9	3	25	C	poor	11.8	N	3.51	0.25	-2.88	-3.36	0.00	14.8	52.0
TNF615-3.6	1	24	PA	fair	9.6	N	0.00	0.64	12.00	11.04	0.00	32.1	0.0
TNF615-3.6	2	24	PA	fair	9.6	N	0.72	0.64	11.52	10.18	0.00	32.1	23.0
TNFcr-0.6	1	40	PA	fair	13.4	N	1.65	0.57	2.16	2.16	0.00	40.1	66.0
TNFcr-0.6	2	40	PA	fair	13.4	N	1.64	0.57	2.16	1.68	0.00	40.2	66.0
TNF662A-0.7	1	29	C	fair	7.0	N	3.09	0.58	10.68	17.28	0.00	31.1	96.0
TNF662A-0.7	2	29	C	fair	7.0	N	2.83	0.58	10.98	12.06	0.00	31.3	88.5
TKNF905-0.1	1	49	PA	fair	9.3	Y	0.73	0.64	NA	-1.56	0.00	36.9	27.0
TKNF905-0.3	1	50	PA	fair	8.0	N	1.04	0.63	NA	1.86	0.00	39.0	40.5
TKNF910-0.9	1	54	C	good	36.9	N	2.08	0.08	3.54	6.60	0.00	35.5	74.0
TKNF910-0.9	2	54	C	good	36.9	N	2.03	0.08	3.54	6.06	0.00	35.5	72.0
TKNF910-0.9	3	54	C	good	36.9	N	1.92	0.08	3.54	5.40	0.00	35.5	68.0
TKNF916-0.7	1	57	PA	fair	10.3	N	1.47	0.54	NA	27.18	0.00	38.4	56.5
TKNF916-0.7	2	57	PA	fair	10.3	N	1.90	0.48	NA	28.14	0.00	38.4	73.0

table continued on next page

Site ID	Pipe #	Forest #	Shape	Pipe Condition	Mean Chnl Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width : Chnl Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
TUNF900-0.9	1	48	C	fair	6.7	N	2.54	0.90	46.20	47.52	0.00	54.4	138.0
TUNFcr54-1.0	1	58	B	good	7.7	N	0.87	0.78	7.56	7.56	0.00	42.1	36.5
TUNF937-0.1	1	56	C	good	6.5	Y	0.19	0.46	-0.60	1.08	0.00	27.0	5.0
ONF29/35-1.5	1	73	B	fair	13.7	N	0.38	0.73	43.32	24.12	0.00	55.5	21.0
ONFyaeger-.001	1	78	C	fair	11.8	N	0.84	0.26	1.56	1.08	0.00	31.1	26.0
ONFyaeger-.001	2	78	C	fair	11.8	N	0.13	0.26	1.68	-1.92	0.00	31.1	4.0
ONFyaeger-.001	3	78	C	fair	11.8	N	0.26	0.26	3.48	-2.64	0.00	31.1	8.0
ONF35-0.2	1	76	C	good	8.0	N	1.93	0.69	1.32	0.24	0.00	39.8	77.0
ONF421-1.9	1	59	B	good	9.0	N (discontin)	0.14	1.34	-6.00	-9.24	6.36	20.8	3.0
TANF707-1.8	1	--	PA	fair	6.0	N	4.00	0.80	9.72	7.68	0.00	40.3	161.0
TANF707-2.5	1	62	C	good	4.7	N	2.57	0.64	34.02	27.72	0.00	38.9	100.0
TANF707-4.5	1	61	C	fair	5.7	N	0.40	0.44	13.80	8.40	0.00	25.0	10.0
TANF707-5.6	1	60	PA	good	9.8	N	2.50	0.61	60.60	55.68	0.00	45.6	114.0
TANF707-5.6	2	60	PA	good	9.8	N	5.61	0.61	44.64	34.20	0.00	45.0	252.5
TANF726-0.4	1	67	PA	good	7.7	N (discontin)	0.29	0.92	-0.12	-2.88	0.00	52.8	15.5
TANF731-1.2	1	69	C	poor	3.0	N	0.30	1.18	-1.32	5.16	0.30	28.0	8.5
TANF751-2.0	1	70	C	good	6.4	N	0.56	1.10	0.00	-2.16	0.00	60.7	34.0
TANF751-3.5	1	72	PA	fair	5.5	Y	0.30	0.91	-0.78	-2.88	0.00	26.9	8.0
TANF50-0.6	1	74	B	good	6.1	Y	0.72	0.99	NA	-4.20	0.00	54.1	39.0
TANF50-2.6	1	75	B	fair	4.5	Y	0.46	1.33	NA	-1.32	0.00	54.6	25.0
TANF708-0.2	1	63	C	fair	4.7	N	2.00	0.43	2.88	1.20	0.00	51.5	103.0
TANF715-1.6	1	66	PA	good	5.0	Y	0.67	1.10	NA	-2.64	0.00	37.5	25.0
TANF726-0.7	1	68	C	fair	4.9	N	0.02	0.62	NA	-1.32	0.00	43.0	1.0
TANF726-0.7	2	68	C	fair	4.9	N	0.49	0.62	NA	1.92	0.00	42.6	21.0

Appendix D: Results for the Francis Marion-Sumter National Forest

We completed surveys at 91 (76%) of 120 documented crossing structures on the Long Cane and Andrew Pickens Ranger Districts in 2006 (Figure D1, Tables D1 and D2). Filter A (strong swimmers and leapers) classified 4% (n=4) of crossings as impassable, 64% (n=58) as passable, and 32% (n=29) as indeterminate (Figure D2, Table D2). Filter B (moderate swimmers and leapers) classified 20% (n=18) of crossings as impassable, 46% (n=42) as passable, and 34% (n=31) as indeterminate (Figure D3, Table D2). Filter C (weak swimmers and leapers) classified 36% (n=33) of crossings as impassable, 42% (n=38) as passable, and 22% (n=20) as indeterminate (Figure D4, Table D2). Characteristics and filter classifications for each crossing are presented in Tables D3-D5.

The majority of the crossings surveyed were circular culverts (68%, n=62), while vented fords (10%, n=9), open bottom arches (10%, n=9), pipe arches (7%, n=6), box culverts (3%, n=3), and fords (2%, n=2) were less frequently encountered. Filter A classified 2% of circular culverts, 0% of vented fords, open bottom arches, and pipe arches, and 33% of box culverts as impassable (Figure D5). Filter B classified 21% of circular culverts, 0% of vented fords and open bottom arches, 17% of pipe arches, and 67% of box culverts as impassable (Figure D6). Filter C classified 37% of circular culverts, 22% of vented fords, 0% of open bottom arches, 50% of pipe arches, and 100% of box culverts as impassable (Figure D7). The 2 fords surveyed were impassable for all 3 filters. The mean crossing width to channel width ratio (excluding fords, vented fords, and multiple structure crossings) was 0.76 ± 0.35 (mean ± SD) (n=63), and 17 crossings were greater than or equal to the bankfull channel width (Figure D8). The mean crossing width to channel width ratio for surveyed crossings classified impassable by Filter A was 1.22 ± 0.00 (n=1). The mean ratio for crossings classified impassable by Filter B was 0.73 ±0.25 (n=13), and was 0.65 ± 0.27 (n=22) for Filter C (Figure D9). The mean crossing width to channel width ratio for surveyed crossings classified passable by Filter A was 0.79 ± 0.39 (n=39). The mean ratio for crossings classified passable by Filter B was 0.83 ±0.42 (n=28), and was 0.86 ± 0.41 (n=26) for Filter C (Figure D9).

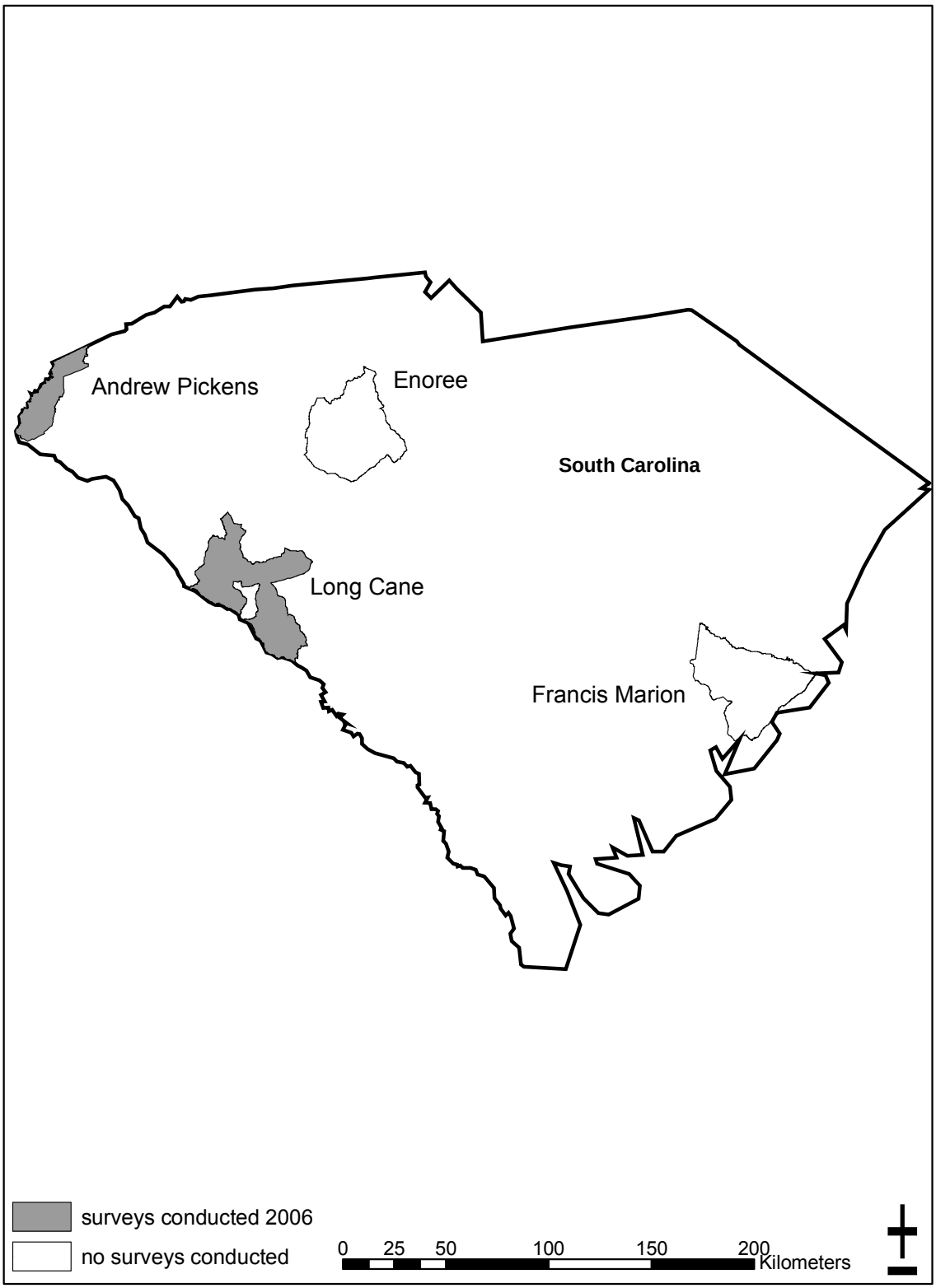

Figure D1. Ranger Districts on the Francis Marion-Sumter National Forest road-stream crossing surveys were conducted, April 2006.

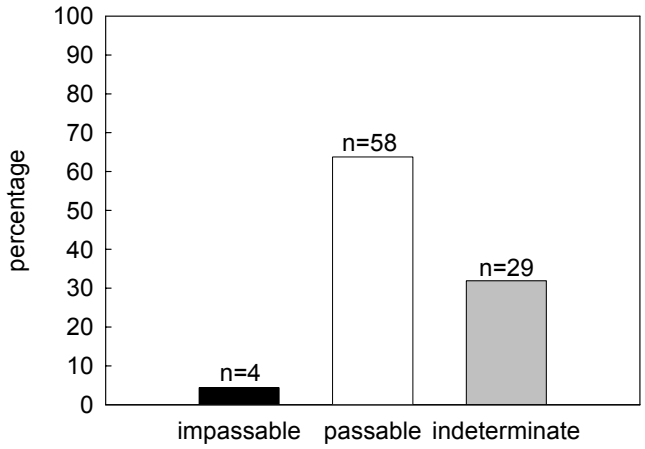

Figure D2. Percentage of crossings classified as impassable, passable, or indeterminate for Filter A; Francis Marion-Sumter National Forest, April 2006 (N=91).

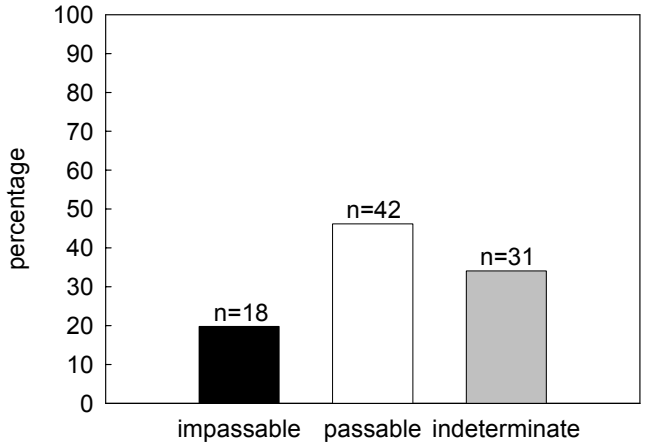

Figure D3. Percentage of crossings classified as impassable, passable, or indeterminate for Filter B; Francis Marion-Sumter National Forest, April 2006 (N=91).

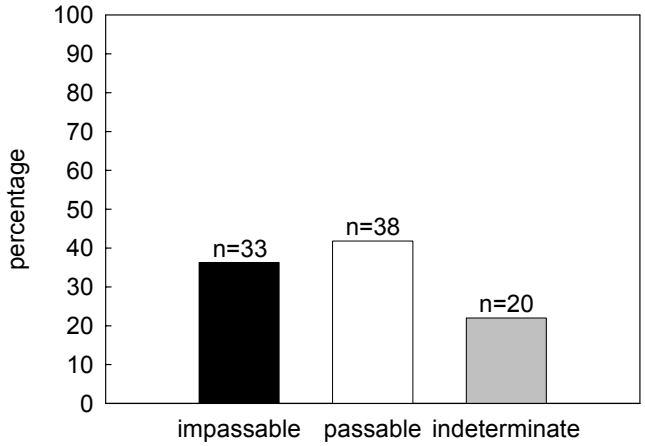

Figure D4. Percentage of crossings classified as impassable, passable, or indeterminate for Filter C; Francis Marion-Sumter National Forest, April 2006 (N=91).

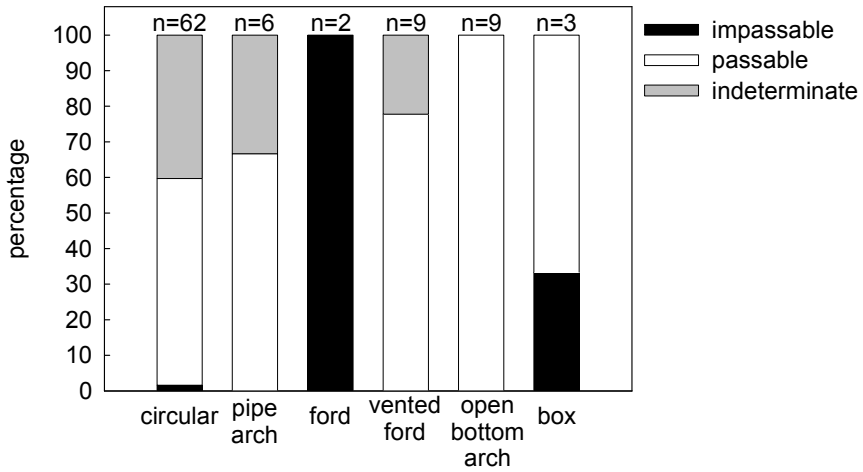

Figure D5. Percentage of each crossing type classified as impassable, passable, or indeterminate for Filter A; Francis Marion-Sumter National Forest, April 2006 (N=91).

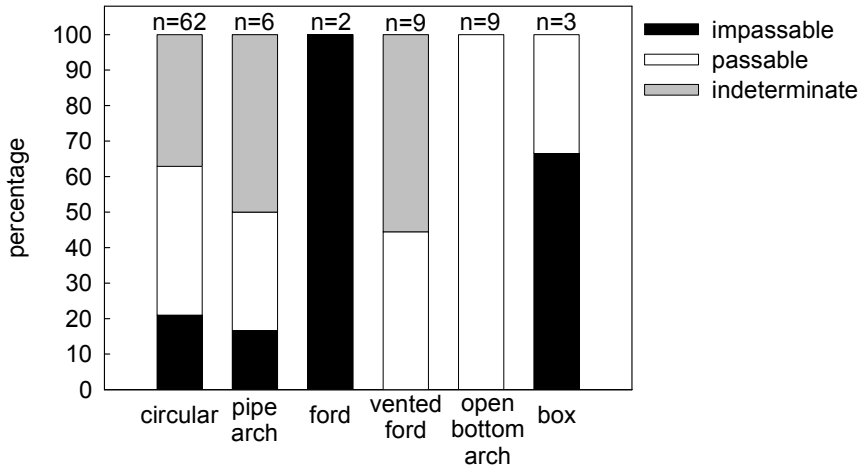

Figure D6. Percentage of each crossing type classified as impassable, passable, or indeterminate for Filter B; Francis Marion-Sumter National Forest, April 2006 (N=91).

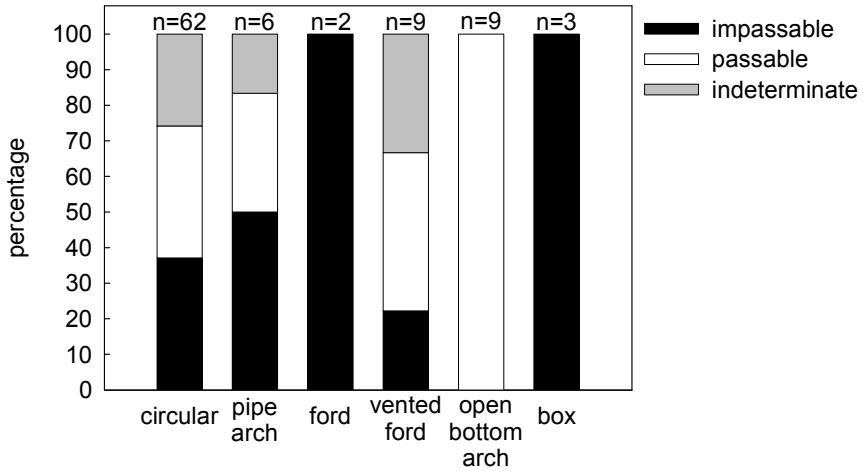

Figure D7. Percentage of each crossing type classified as impassable, passable, or indeterminate for Filter C; Francis Marion-Sumter National Forest, April 2006 (N=91).

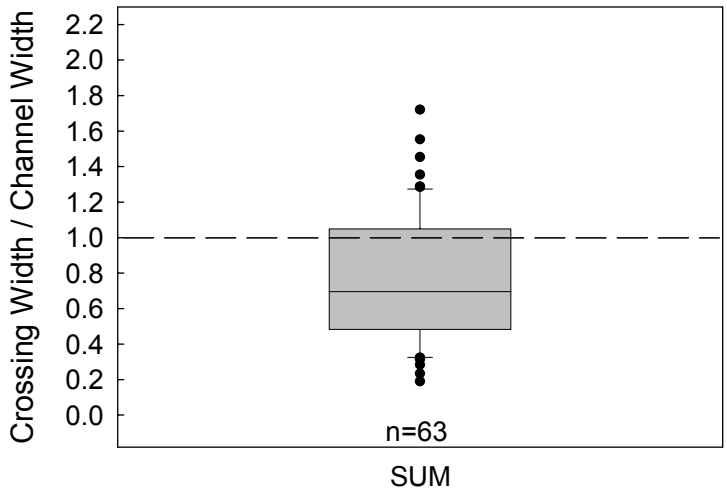

Figure D8. Crossing width to bankfull channel width ratio for crossings surveyed in April 2006 on the Francis Marion-Sumter National Forest (excluding fords, vented fords, and multiple structure crossings). A ratio of 1.0 (dashed line) or greater indicates the crossing structure opening is greater than or equal to the bankfull channel width. The top and bottom of the boxes represent the 25th and 75th percentiles, the bar in the center of each box represents the median, whiskers represent the 10th and 90th percentiles, and closed circles represent the entire range of the data.

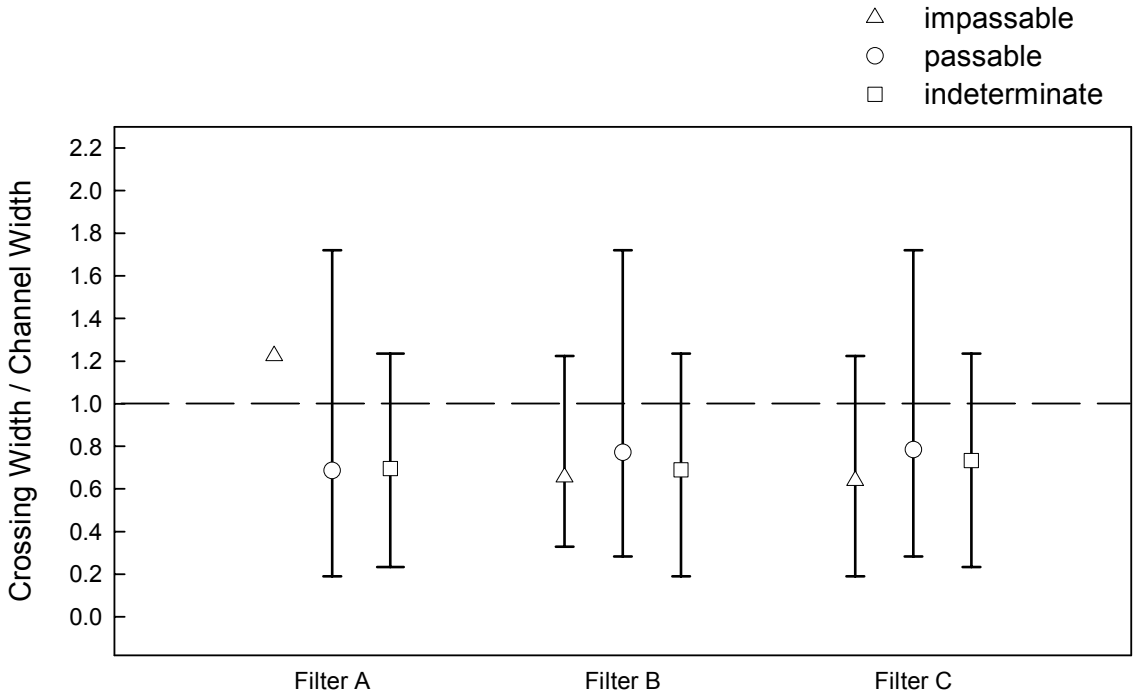

Figure D9. Crossing width to bankfull channel width ratio for crossings classified as impassable, passable, or indeterminate in April 2006 on the Francis Marion-Sumter National Forest (excluding fords, vented fords, and multiple structure crossings). A ratio of 1.0 (dashed line) or greater indicates the crossing structure opening is greater than or equal to the bankfull channel width. The symbol inside each set of whiskers represents the median, and the top and bottom of the whiskers represent the maximum and minimum values.

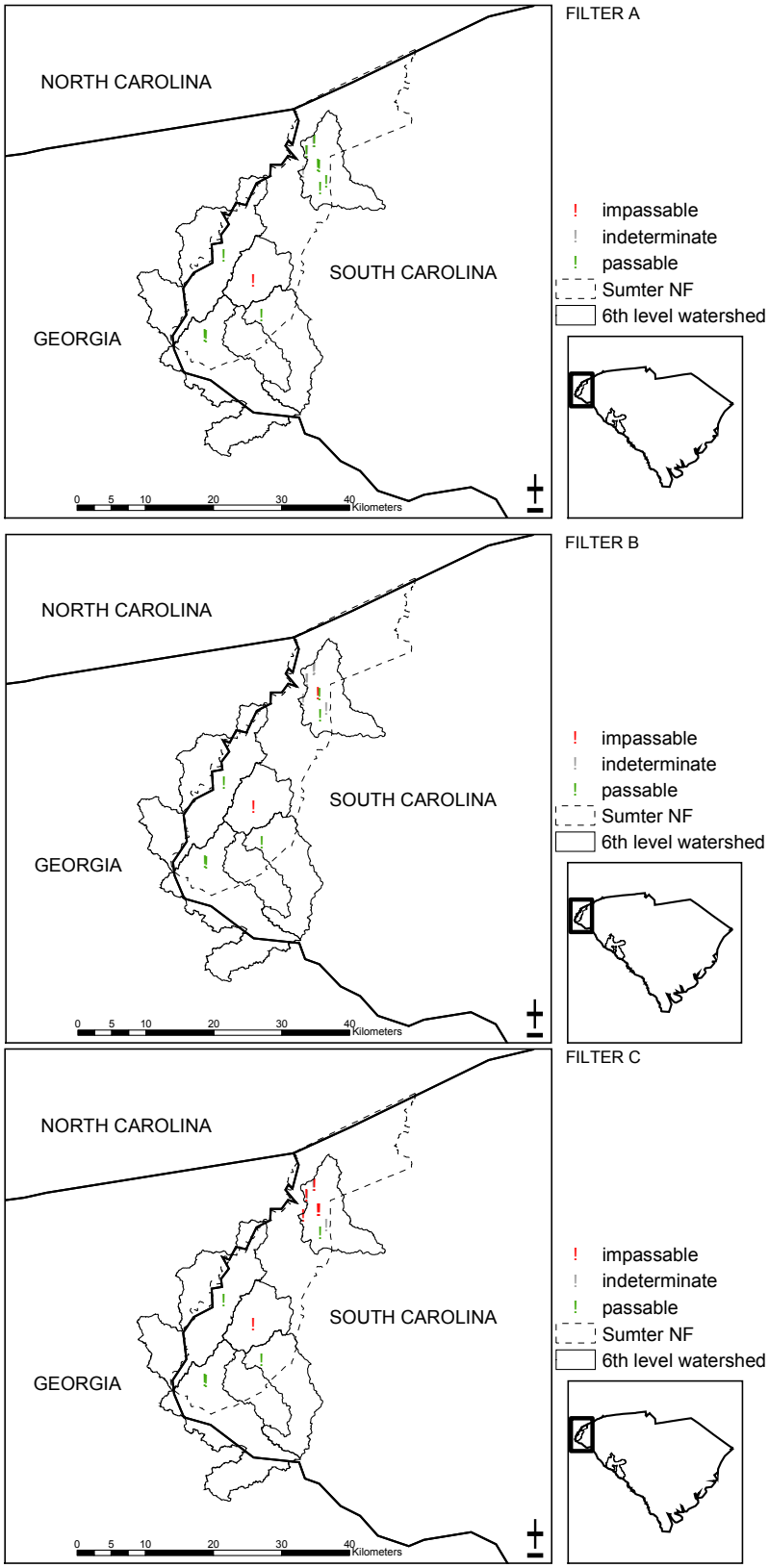

Figure D10. Location of crossings classified for fish passage by coarse filters A, B, and C within 6th level watersheds on the Francis Marion-Sumter National Forest Andrew Pickens Ranger District, April 2006.

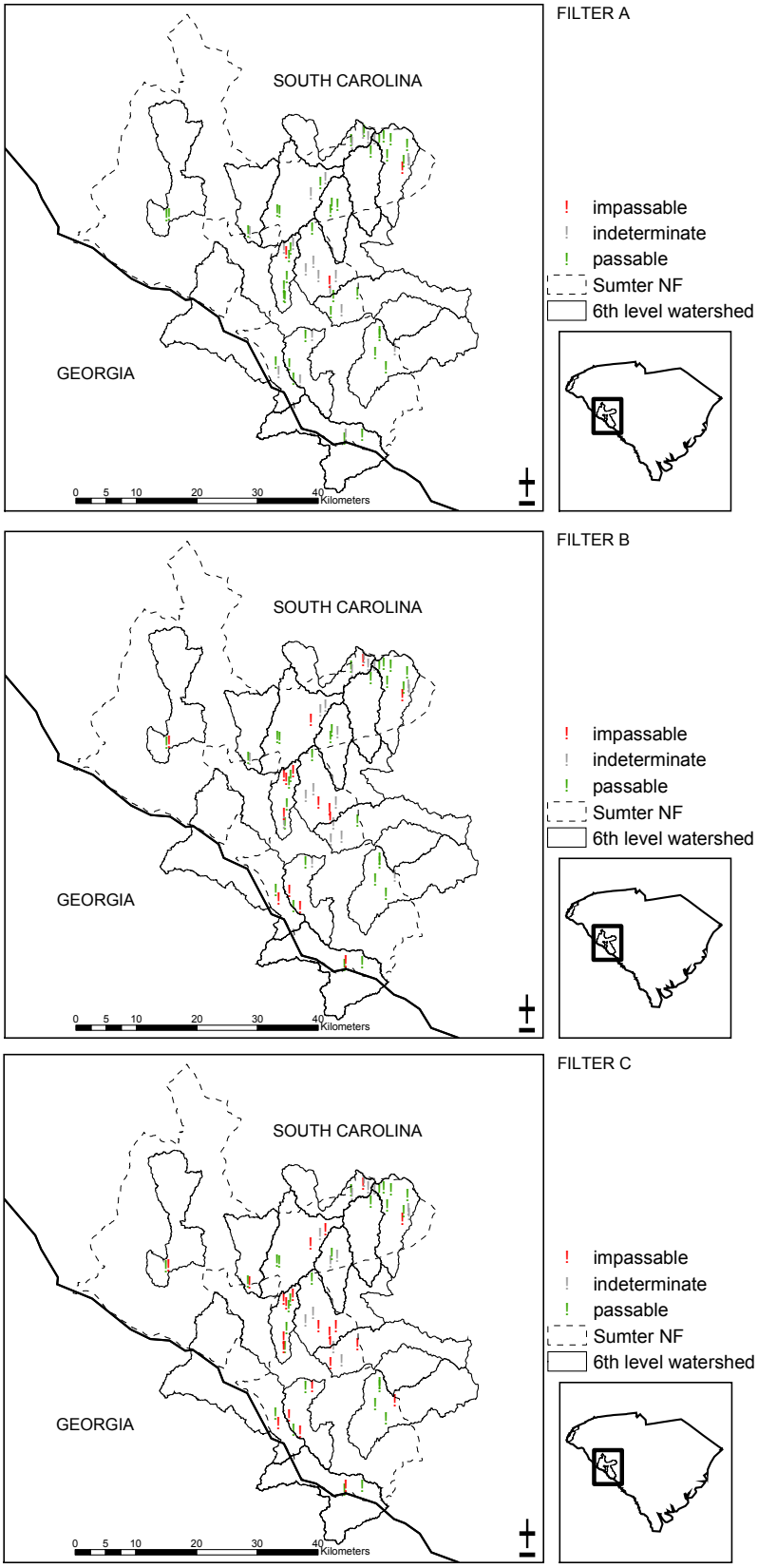

Figure D11. Location of crossings classified for fish passage by coarse filters A, B, and C within 6th level watersheds on the Francis Marion-Sumter National Forest Long Cane Ranger District, April 2006.

Table D1. Number of crossings documented (Total crossings documented) and not surveyed (Crossings not surveyed) on the Francis Marion-Sumter National Forest, April 2006. Reasons for not surveying a documented site include: no suitable fish habitat upstream of crossing (NH); no access to site due to closed roads or private gates (NA); crossing was a natural ford (NF); crossing was a bridge (BR).

Forest	Total crossings documented	Crossings not surveyed (n, [%])				
		NH	NA	NF	BR	Total not surveyed
SNF	120	18 (62)	7 (24)	4 (14)	0 (0)	29 (24)

Table D2. Number of crossings surveyed (Total surveyed) with coarse filter results for the Francis Marion-Sumter National Forest, April 2006. Coarse filter results are presented for Filter A, Filter B, and Filter C (see filter descriptions, Fig 3 – 5).

Forest	Total surveyed	Coarse filter results								
		Impassable (n, [%])			Passable (n, [%])			Indeterminate (n, [%])		
		A	B	C	A	B	C	A	B	C
SNF	91	4 (4)	18 (20)	33 (36)	58 (64)	42 (46)	38 (42)	29 (32)	31 (34)	20 (22)

Table D3. Location of crossings surveyed in Francis-Marion-Sumter National Forest, April 2006. Site ID consists of the Forest abbreviation (SNF), road the crossing is on (108), and the distance (miles) from the junction road (1.3).

Site ID	# of Pipes	District	Junction Road	Stream Name	Quad	6th Level Watershed
SNF108-1.3	1	Andrew Pickens	107	UT Crane Creek	Tamassee	SNF108-1.3
SNF709-0.4	1	Andrew Pickens	107	UT Moody Creek	Tamassee	SNF709-0.4
SNF710-0.7	1	Andrew Pickens	107	Crane Creek	Tamassee	SNF710-0.7
SNF710-3.1	1	Andrew Pickens	107	Cane Creek	Tamassee	SNF710-3.1
SNF710-3.3	1	Andrew Pickens	107	West Fork Townes	Tamassee	SNF710-3.3
SNF715a-0.6	1	Andrew Pickens	107	Wash Branch	Tamassee	SNF715a-0.6
SNF722-0.4	1	Andrew Pickens	107	UT Moody Creek	Tamassee	SNF722-0.4
SNF733-0.5	1	Andrew Pickens	710	Jumping Branch	Tamassee	SNF733-0.5
SNF750-0.45	1	Andrew Pickens	fh108	Tamassee Creek	Tamassee	SNF750-0.45
SNF745-0.4	1	Andrew Pickens	C37PU7	Fall Creek	Whetstone	SNF745-0.4
SNFFH104-1.4	1	Andrew Pickens	fh104	Double Branch	Tugaloo Lake	SNFFH104-1.4
SNF709-0.3	1	Andrew Pickens	pavement to gravel	Brasstown Creek	Tugaloo Lake	SNF709-0.3
SNF733-0.51	1	Andrew Pickens	290	UT Chauga River	Whetstone	SNF733-0.51
SNF751-0.15	1	Andrew Pickens	Rocky Fork Road	Rocky Fork Creek	Holly Springs	SNF751-0.15
SNF632A-1.0	1	Long Cane	632	UT Stevens Creek	Clarks Hill	SNF632A-1.0
SNF652-0.9	1	Long Cane	384	UT Ray Creek	Clarks Hill	SNF652-0.9
SNF565-0.8	1	Long Cane	570	UT Clarks Hill Lake	McCormick	SNF565-0.8
SNF565-1.2	1	Long Cane	570	UT Clarks Hill Lake	McCormick	SNF565-1.2
SNF656-0.3	1	Long Cane	659b	Stevens Creek	Martinez	SNF656-0.3
SNF660-0.8	2	Long Cane	28	Maulden Branch	Martinez	SNF660-0.8
SNF660E-0.4	1	Long Cane	660	UT Savannah	Martinez	SNF660E-0.4
SNF576a-1.1	1	Long Cane	378	UT Hard Labor Creek	Winterseat	SNF576a-1.1
SNF576a-1.3	1	Long Cane	378	UT Hard Labor Creek	Winterseat	SNF576a-1.3
SNF24589-0.4	4	Long Cane	104	UT Horsepen Creek	Kirksey	SNF24589-0.4
SNF589-0.2	1	Long Cane	30	UT Horsepen Creek	Good Hope	SNF589-0.2
SNF589A-0.5	1	Long Cane	24589	UT Horsepen Creek	Kirksey	SNF589a-0.5
SNF589A-0.8	1	Long Cane	24589	UT Horsepen Creek	Kirksey	SNF589a-0.8
SNF589D-0.2	1	Long Cane	589	UT Horsepen Creek	Kirksey	030601070106
SNF574-0.6	1	Long Cane	316	UT Cuffytown Creek	Limestone	030601070107
SNF668-0.4	1	Long Cane	668A	UT Little Horsepen Creek	Limestone	030601070107
SNF668-1.2	1	Long Cane	668A	UT Little Horsepen Creek	Limestone	030601070107

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Site ID	# of Pipes	District	Junction Road	Stream Name	Quad	6th Level Watershed
SNF679A-0.35	1	Long Cane	519	UT Lick Creek	Winterseat	030601070107
SNF679A-0.65	1	Long Cane	519	UT Lick Creek	Winterseat	030601070107
SNF138-0.3	1	Long Cane	605	Byrd Creek	Winterseat	030601070110
SNF602-0.2	1	Long Cane	604	Byrd Creek	Winterseat	030601070110
SNF604-0.5	1	Long Cane	138	Byrd Creek	Winterseat	030601070110
SNF604-1.2	1	Long Cane	138	UT Byrd Creek	Winterseat	030601070110
SNF613B-0.2	1	Long Cane	118	UT Byrd Creek	Parksville	030601070110
SNF615-1.8	1	Long Cane	138	UT Byrd Creek	Parksville	030601070110
SNF615-2.0	2	Long Cane	138	UT Byrd Creek	Parksville	030601070110
SNF672-1.0	1	Long Cane	138	UT Byrd Creek	Parksville	030601070110
SNF688-0.6	1	Long Cane	283	UT Byrd Creek	Parksville	030601070110
SNF590A-0.1	1	Long Cane	590	UT Flat Rock Branch	Good Hope	030601070203
SNF590A-0.7	1	Long Cane	590	UT Flat Rock Branch	Good Hope	030601070203
SNF591-1.0	1	Long Cane	38	UT Sleepy Creek	Good Hope	030601070203
SNF592D-0.3	1	Long Cane	592	UT Sleepy Creek	Good Hope	030601070203
SNF592E-0.1	3	Long Cane	592D	Sleepy Creek	Good Hope	030601070203
SNF595-0.1	2	Long Cane	594	Ephriam Branch	Good Hope	030601070203
SNF595-1.5	3	Long Cane	594	Ephriam Branch	Owdoms	030601070203
SNF595-2.0	2	Long Cane	594	UT Ephriam Branch	Owdoms	030601070203
SNF665-1.7	1	Long Cane	591	UT Ephriam Branch	Owdoms	030601070203
SNF665A 0.6	1	Long Cane	C41-665	UT Ephriam Branch	Owdoms	030601070203
SNF609-0.4	1	Long Cane	137	UT Cyper Creek	Red Hill	030601070204
SNF610A-0.6	1	Long Cane	610B	Cyper Creek	Parksville	030601070204
SNF610B-0.7	1	Long Cane	283	UT Bryd Creek	Parksville	030601070204
SNF611-0.3	1	Long Cane	137	Broadwater Branch	Red Hill	030601070204
SNF611-1.4	1	Long Cane	137	UT Turkey Cree	Red Hill	030601070204
SNF621-0.9	1	Long Cane	137	Goff Branch	Red Hill	030601070204
SNF624-0.2	1	Long Cane	621	UT Turkey Creek	Red Hill	030601070204
SNF663-0.6	2	Long Cane	378	UT Cyper Creek	Limestone	030601070204
SNF458-0.3	1	Long Cane	30	UT Talbert Branch	Good Hope	030601070205
SNF585B-0.2	2	Long Cane	585	Stockman Branch	Limestone	030601070207
SNF585B-1.0	1	Long Cane	585	UT Stockman Branch	Limestone	030601070207
SNF585C-0.3	1	Long Cane	585	Wilson Branch	Limestone	030601070207

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Site ID	# of Pipes	District	Junction Road	Stream Name	Quad	6th Level Watershed
SNF624-0.8	1	Long Cane	621	UT Beaverdam Creek	Red Hill	030601070301
SNF625-0.1	1	Long Cane	51	UT Beaverdam Creek	Red Hill	030601070301
SNF625-0.1	2	Long Cane	51	UT Beaverdam Creek	Red Hill	030601070301
SNF625-1.9	1	Long Cane	131	UT Beaverdam Creek	Red Hill	030601070301
SNFC19-625-0.6	1	Long Cane	68	Red Hill Spring Branch	Red Hill	030601070301
SNFC19-625-0.6	2	Long Cane	68	Red Hill Spring Branch	Red Hill	030601070301
SNFC19-625-0.6	3	Long Cane	68	Red Hill Spring Branch	Red Hill	030601070301
SNF629A-0.6	1	Long Cane	629	UT Buzzard Branch	Parksville	030601070401
SNF629C-0.8	1	Long Cane	629	UT Buzzard Branch	Parksville	030601070401
SNF643-0.5	1	Long Cane	644	Buzzard Branch	Clarks Hill	030601070401
SNF644A-0.3	1	Long Cane	644	UT Stevens Creek	Clarks Hill	030601070401
SNF699-0.5	1	Long Cane	28	UT Stevens Creek	Clarks Hill	030601070401
SNF638-1.4	1	Long Cane	C19-638	UT Horn Creek	Colliers	030601070406
SNF640-1.7	1	Long Cane	230	Fork Branch	Colliers	030601070406
SNF641-0.6	1	Long Cane	634	UT Rock Creek	Colliers	030601070406
SNF641-0.9	1	Long Cane	634	UT Rock Creek	Colliers	030601070406
SNF642B-0.2	1	Long Cane	52	UT Horn Creek	Colliers	030601070406

Table D4. Coarse filters A, B, and C, classifications for surveyed crossings in Francis Marion-Sumter National Forest, April 2006.

Site ID	Pipe #	Filter A	Filter B	Filter C
SNF108-1.3	1	passable	indeterminate	indeterminate
SNF709-0.4	1	passable	indeterminate	impassable
SNF710-0.7	1	indeterminate	indeterminate	impassable
SNF710-3.1	1	passable	impassable	impassable
SNF710-3.3	1	passable	passable	impassable
SNF715a-0.6	1	passable	passable	passable
SNF722-0.4	1	passable	passable	passable
SNF733-0.5	1	indeterminate	indeterminate	indeterminate
SNF750-0.45	1	passable	passable	passable
SNF745-0.4	1	impassable	impassable	impassable
SNF709-0.3	1	indeterminate	indeterminate	indeterminate
SNFFH104-1.4	1	passable	passable	passable
SNF733-0.51	1	passable	indeterminate	impassable
SNF751-0.15	1	passable	passable	passable
SNF632A-1.0	1	passable	passable	passable
SNF652-0.9	1	indeterminate	impassable	impassable
SNF565-0.8	1	passable	impassable	impassable
SNF565-1.2	1	passable	passable	passable
SNF656-0.3	1	passable	passable	passable
SNF660-0.8	1	impassable	impassable	impassable
SNF660-0.8	2	indeterminate	impassable	impassable
SNF660E-0.4	1	passable	passable	passable
SNF576a-1.1	1	passable	passable	passable
SNF576a-1.3	1	indeterminate	indeterminate	impassable
SNF24589-0.4	3	passable	passable	passable
SNF24589-0.4	4	passable	passable	passable
SNF589-0.2	1	indeterminate	indeterminate	indeterminate
SNF589a-0.5	1	indeterminate	impassable	impassable
SNF589a-0.8	1	passable	indeterminate	indeterminate
SNF589d-0.2	1	indeterminate	indeterminate	indeterminate
SNF574-0.6	1	indeterminate	impassable	impassable
SNF668-0.4	1	passable	indeterminate	indeterminate
SNF668-1.2	1	indeterminate	indeterminate	impassable
SNF679a-0.35	1	passable	passable	passable
SNF679a-0.65	1	passable	passable	passable
SNF138-0.3	1	indeterminate	impassable	impassable
SNF602-0.2	1	indeterminate	impassable	impassable
SNF604-0.5	1	passable	passable	passable
SNF604-1.2	1	impassable	impassable	impassable
SNF613B-0.2	1	passable	impassable	impassable
SNF615-1.8	1	passable	passable	passable
SNF615-2.0	1	indeterminate	impassable	impassable
SNF615-2.0	2	passable	indeterminate	impassable
SNF672-1.0	1	passable	passable	passable
SNF688-0.6	1	passable	passable	passable

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Site ID	Pipe #	Filter A	Filter B	Filter C
SNF590a-0.1	1	indeterminate	indeterminate	indeterminate
SNF590A-0.7	1	passable	passable	passable
SNF591-1.0	1	passable	passable	passable
SNF592D-0.3	1	passable	passable	passable
SNF592E-0.1	1	passable	passable	passable
SNF592E-0.1	2	passable	passable	passable
SNF592E-0.1	3	passable	passable	passable
SNF595-0.1	1	passable	indeterminate	impassable
SNF595-0.1	2	passable	passable	passable
SNF595-1.5	1	passable	indeterminate	indeterminate
SNF595-1.5	2	passable	indeterminate	indeterminate
SNF595-1.5	3	indeterminate	indeterminate	indeterminate
SNF595-2.0	1	indeterminate	indeterminate	indeterminate
SNF595-2.0	2	indeterminate	indeterminate	indeterminate
SNF665-1.7	1	passable	passable	passable
SNF665A 0.6	1	indeterminate	indeterminate	indeterminate
SNF609-0.4	1	indeterminate	impassable	impassable
SNF610a-0.6	1	indeterminate	indeterminate	indeterminate
SNF610b-0.7	1	indeterminate	indeterminate	indeterminate
SNF611-0.3	1	impassable	impassable	impassable
SNF611-1.4	1	indeterminate	indeterminate	impassable
SNF621-0.9	1	passable	passable	passable
SNF624-0.2	1	indeterminate	impassable	impassable
SNF663-0.6	1	passable	passable	passable
SNF663-0.6	2	passable	passable	passable
SNF458-0.3	1	passable	passable	passable
SNF585b-0.2	1	passable	passable	passable
SNF585b-0.2	2	passable	passable	passable
SNF585b-1.0	1	passable	indeterminate	indeterminate
SNF585c-0.3	1	passable	passable	indeterminate
SNF624-0.8	1	passable	indeterminate	indeterminate
SNF625-0.1	1	passable	passable	impassable
SNF625-0.1	2	passable	passable	impassable
SNF625-1.9	1	indeterminate	indeterminate	indeterminate
SNFC19-625-0.6	2	passable	indeterminate	impassable
SNFC19-625-0.6	3	indeterminate	indeterminate	impassable
SNF629A-0.6	1	indeterminate	indeterminate	impassable
SNF629C-0.8	1	passable	passable	passable
SNF643-0.5	1	passable	passable	passable
SNF644A-0.3	1	indeterminate	impassable	impassable
SNF699-0.5	1	passable	impassable	impassable
SNF638-1.4	1	passable	passable	passable
SNF640-1.7	1	passable	passable	passable
SNF641-0.6	1	passable	passable	passable
SNF641-0.9	1	passable	passable	passable
SNF642B-0.2	1	indeterminate	indeterminate	impassable

Table D5. Description of crossings surveyed in Francis Marion-Sumter National Forest, April 2006. Shape abbreviations: C= circular, PA= pipe arch, OBA= open bottom arch, and F= ford. Channel width is the mean bankfull channel width. N= no natural substrate, N (discontin)= discontinuous substrate, Y= continuous natural substrate. An NA (not applicable) indicates outlet drop (no outlet pool or tailwater control) or outlet perch (stream dry) could not be calculated. Negative outlet drop or perch values indicate a submerged outlet (structure partially backwatered). Residual inlet depth values ≥ 0.0 indicate the structure is fully backwatered.

Site ID	Pipe #	Shape	Pipe Condition	Mean Channel Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width: Channel Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
SNF108-1.3	1	PA	fair	8.6	N (discontin)	0.52	1.12	NA	-4.68	0.00	52.0	27.0
SNF709-0.4	1	C	good	8.3	N	1.23	0.36	7.26	2.40	0.00	30.5	37.5
SNF710-0.7	1	C	fair	7.7	N	1.61	0.32	5.16	-9.72	0.00	56.4	91.0
SNF710-3.1	1	B	good	14.7	N	1.84	0.58	16.26	11.16	0.00	22.8	42.0
SNF710-3.3	1	B	good	12.5	N	1.04	0.32	8.40	3.42	0.00	19.8	20.5
SNF715a-0.6	1	VF	good	16.6	Y	1.47	0.30	-12.96	-20.52	17.40	25.2	37.0
SNF722-0.4	1	OBA	good	9.1	Y	0.15	1.45	NA	-1.92	0.00	59.3	9.0
SNF733-0.5	1	C	fair	3.8	N	3.13	0.33	-1.44	-4.68	0.00	17.9	56.0
SNF750-0.45	1	OBA	good	19.8	Y	0.01	0.79	-7.38	-15.66	7.32	47.1	0.5
SNF745-0.4	1	F	fair	9.6	N	17.00	NA	3.84	-0.48	0.00	31.0	527.0
SNF709-0.3	1	C	good	8.3	N	2.03	0.48	NA	-4.08	0.00	28.1	57.0
SNFFH104-1.4	1	OBA	good	21.3	Y	1.78	0.78	-7.80	-10.74	11.34	16.6	29.5
SNF733-0.51	1	C	fair	7.9	N	1.77	0.19	5.28	1.38	0.00	17.5	31.0
SNF751-0.15	1	OBA	good	10.8	Y	2.24	1.26	NA	1.62	0.00	39.0	87.5
SNF632A-1.0	1	OBA	good	13.0	Y	0.05	1.08	-5.04	-5.52	5.16	20.6	1.0
SNF652-0.9	1	C	good	7.7	N	0.96	0.52	12.48	7.20	0.00	59.5	57.0
SNF565-0.8	1	C	good	6.3	N	0.40	0.79	17.70	14.70	0.00	36.5	14.5
SNF565-1.2	1	C	fair	9.4	Y	0.62	0.37	-10.44	-13.08	6.36	55.0	34.0
SNF656-0.3	1	C	poor	10.1	Y	1.86	1.29	NA	13.32	0.00	48.3	90.0
SNF660-0.8	1	C	fair	5.9	N	0.97	1.02	24.96	23.04	0.00	64.0	62.0
SNF660-0.8	2	C	fair	5.9	N	3.00	1.02	15.60	13.56	0.00	61.4	184.0

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Site ID	Pipe #	Shape	Pipe Condition	Mean Channel Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width: Channel Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
SNF660E-0.4	1	C	fair	5.8	N	0.05	0.43	NA	-10.20	0.00	41.2	2.0
SNF576A-1.1	1	PA	poor	7.9	Y	1.04	0.63	-9.72	-10.80	4.62	40.9	42.5
SNF576A-1.3	1	PA	poor	6.3	N	2.92	0.56	NA	2.34	0.00	60.9	178.0
SNF24589-0.4	3	C	good	14.1	N (discontin)	0.41	0.43	-3.00	-8.16	1.20	37.0	15.0
SNF24589-0.4	4	C	good	14.1	N (discontin)	0.50	0.43	-0.78	-2.04	3.00	37.0	18.5
SNF589-0.2	1	C	fair	8.6	N	2.53	0.23	2.64	-0.96	0.00	22.7	57.5
SNF589A-0.5	1	C	poor	4.1	N	4.49	0.73	-3.48	-7.56	0.00	35.0	157.0
SNF589A-0.8	1	C	good	6.6	N	1.11	0.46	1.56	-0.84	0.00	32.0	35.5
SNF589D-0.2	1	C	fair	6.1	N	1.56	0.74	-0.06	-2.88	0.00	40.6	63.5
SNF574-0.6	1	C	good	7.6	N	2.32	0.33	18.00	16.44	0.00	25.0	58.0
SNF668-0.4	1	C	good	5.6	N	0.90	1.07	0.18	-0.78	0.00	55.4	50.0
SNF668-1.2	1	C	good	3.7	N	2.83	1.09	5.76	3.06	0.00	38.2	108.0
SNF679A-0.35	1	C	poor	6.0	N	0.35	0.58	-9.24	-9.12	11.28	48.5	17.0
SNF679A-0.65	1	C	poor	6.5	N	1.71	0.77	-12.90	-11.58	3.36	46.5	79.5
SNF138-0.3	1	C	good	8.1	N	3.42	1.14	-7.80	-10.56	0.00	61.7	211.0
SNF602-0.2	1	C	fair	8.6	N	3.52	0.58	0.48	0.72	0.00	30.4	107.0
SNF604-0.5	1	OBA	good	11.9	Y	1.67	1.17	-5.04	-5.40	1.32	18.6	31.0
SNF604-1.2	1	F	poor	10.3	N	0.75	0.00	25.20	21.96	0.00	16.6	12.5
SNF613B-0.2	1	C	fair	8.0	N	0.12	0.63	20.52	24.78	0.00	32.7	4.0
SNF615-1.8	1	C	poor	8.8	N	2.32	0.28	-5.28	-6.12	12.24	25.0	58.0
SNF615-2.0	1	PA	poor	6.4	N	4.21	0.36	8.46	9.36	4.02	24.7	104.0
SNF615-2.0	2	PA	poor	6.4	N	1.06	0.23	7.80	8.70	0.00	26.0	27.5
SNF672-1.0	1	PA	fair	10.1	N (discontin)	0.49	0.79	-3.06	-3.78	0.60	42.0	20.5
SNF688-0.6	1	OBA	good	10.3	Y	3.15	1.55	-6.72	-7.32	0.00	20.8	65.5
SNF590A-0.1	1	C	good	5.1	N	2.69	1.24	-1.20	-3.60	0.00	34.7	93.5

Table continued next page…

Site ID	Pipe #	Shape	Pipe Condition	Mean Channel Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width: Channel Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
SNF590A-0.7	1	C	fair	5.1	N (discontin)	0.51	1.29	-3.84	-5.64	1.32	41.5	21.0
SNF591-1.0	1	C	good	6.2	N	0.27	0.48	-10.08	-12.96	8.28	56.3	15.0
SNF592D-0.3	1	C	good	3.9	N	0.10	0.64	0.24	-1.68	0.24	38.3	4.0
SNF592E-0.1	1	VF	good	6.3	N	0.98	0.16	-1.20	-3.60	3.12	16.3	16.0
SNF592E-0.1	2	VF	good	6.3	N	0.00	0.16	-1.92	-4.32	1.92	16.3	0.0
SNF592E-0.1	3	VF	good	6.3	N	0.37	0.16	-0.84	-3.24	0.12	16.3	6.0
SNF595-0.1	1	C	fair	8.3	N	1.67	0.36	6.96	19.80	0.00	21.0	35.0
SNF595-0.1	2	C	fair	8.3	N	5.62	0.36	-19.08	-6.24	4.92	21.0	118.0
SNF595-1.5	1	VF	good	8.0	N	1.98	0.12	-1.14	-2.58	0.00	25.2	50.0
SNF595-1.5	2	VF	good	8.0	N	1.93	0.12	-1.14	-2.58	0.00	26.2	50.5
SNF595-1.5	3	VF	good	8.0	N	2.21	0.12	-1.14	-2.58	0.00	26.2	58.0
SNF595-2.0	1	C	good	5.3	N	2.48	0.75	1.92	-0.36	0.00	37.5	93.0
SNF595-2.0	2	C	good	5.3	N	2.61	0.75	2.88	0.60	0.00	37.5	98.0
SNF665-1.7	1	C	fair	12.7	N	1.44	0.32	-6.48	4.68	10.32	22.2	32.0
SNF665A 0.6	1	C	poor	8.2	N	2.06	0.68	0.96	0.48	0.00	59.7	123.0
SNF609-0.4	1	C	fair	7.7	N	1.29	0.91	10.02	9.54	0.00	40.2	52.0
SNF610A-0.6	1	C	good	8.2	N	2.14	0.73	-2.10	-4.38	0.00	40.4	86.5
SNF610B-0.7	1	C	good	5.1	N	1.96	0.79	-2.52	-3.12	0.00	32.6	64.0
SNF611-0.3	1	B	good	8.2	N	0.97	1.22	NA	17.52	0.00	36.1	35.0
SNF611-1.4	1	C	poor	8.7	N	0.96	0.81	7.68	6.00	0.00	56.4	54.0
SNF621-0.9	1	OBA	good	NA	Y	NA	NA	NA	NA	NA	NA	NA
SNF624-0.2	1	C	poor	9.2	N	2.20	0.65	17.76	15.24	0.00	50.0	110.0
SNF663-0.6	1	C	poor	7.0	N	0.94	0.29	-4.02	-6.42	1.26	24.5	23.0
SNF663-0.6	2	C	poor	7.0	N	0.65	0.29	-0.48	8.52	2.10	20.7	13.5
SNF458-0.3	1	C	good	5.8	N	1.78	0.69	2.52	-0.24	7.56	47.3	84.0

Table continued next page…

Site ID	Pipe #	Shape	Pipe Condition	Mean Channel Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width: Channel Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
SNF585B-0.2	1	C	fair	10.9	N (discontin)	1.41	0.64	-12.48	-15.96	5.52	41.0	58.0
SNF585B-0.2	2	C	fair	10.9	N (discontin)	0.71	0.64	-5.40	-8.88	8.88	41.0	29.0
SNF585B-1.0	1	C	fair	6.5	N	0.79	0.93	3.24	-4.80	0.00	38.2	30.0
SNF585C-0.3	1	C	good	8.7	N	0.62	0.46	-1.56	-2.76	0.00	28.9	18.0
SNF624-0.8	1	C	poor	4.0	N	0.62	0.62	-0.24	0.60	0.00	51.5	32.0
SNF625-0.1	1	C	fair	7.1	N	0.52	0.63	6.84	0.72	0.00	48.0	25.0
SNF625-0.1	2	C	fair	7.1	N	0.13	0.63	8.52	2.40	0.00	48.0	6.0
SNF625-1.9	1	C	fair	6.3	N	2.09	1.03	-1.92	-3.72	0.00	45.0	94.0
SNFC19-625-0.6	2	VF	good	11.5	N	1.32	0.13	7.02	4.14	0.00	24.3	32.0
SNFC19-625-0.6	3	VF	good	11.5	N	1.73	0.13	7.02	4.14	0.00	24.3	42.0
SNF629A-0.6	1	C	fair	6.5	N	2.48	0.70	8.94	8.94	0.00	40.1	99.5
SNF629C-0.8	1	C	fair	7.7	N (discontin)	1.78	0.52	-22.98	-17.28	15.12	36.9	65.5
SNF643-0.5	1	C	fair	5.0	N	0.22	0.80	1.68	-12.24	0.00	48.2	10.5
SNF644A-0.3	1	C	fair	6.6	N	1.41	0.75	10.56	9.00	0.00	51.6	73.0
SNF699-0.5	1	C	fair	3.8	N	0.70	0.66	12.36	11.76	0.00	37.3	26.0
SNF638-1.4	1	C	good	6.2	N	0.20	0.40	2.52	0.84	0.00	35.1	7.0
SNF640-1.7	1	OBA	good	8.1	Y	3.72	1.72	-5.52	-8.16	18.12	28.2	105.0
SNF641-0.6	1	C	fair	10.3	Y	1.04	1.35	NA	-7.32	0.00	49.8	52.0
SNF641-0.9	1	C	fair	8.1	Y	2.00	1.05	-0.48	-3.72	0.00	67.1	134.0
SNF642B-0.2	1	C	fair	8.3	N	2.37	0.48	NA	4.80	0.00	51.0	121.0

Appendix E: Results for the National Forests in Mississippi

We completed surveys at 69 (72%) of 96 documented crossing structures on the Homochitto and Holly Springs National Forests in 2006 (Figure E1, Tables E1 and E2). Filter A (strong swimmers and leapers) classified 7% (n=5) of crossings as impassable, 54% (n=37) as passable, and 39% (n=27) as indeterminate (Figure E2, Table E2). Filter B (moderate swimmers and leapers) classified 28% (n=19) of crossings as impassable, 30% (n=21) as passable, and 42% (n=29) as indeterminate (Figure E3, Table E2). Filter C (weak swimmers and leapers) classified 38% (n=26) of crossing as impassable, 27% (n=19) as passable, and 35% (n=24) as indeterminate (Figure E4, Table E2). Characteristics and filter classifications for each crossing are presented in Tables E3-E5.

The majority of the crossings surveyed were circular culverts (65%, n=45), while box culverts (25%, n=17), pipe arches (7%, n=5), fords (3%, n=2), vented fords (0%, n=0), and open bottom arches (0%, n=0) were less frequently encountered or not encountered. Filter A classified 8% of circular culverts, 6% of box culverts, 0% of pipe arches, and fords as impassable (Figure E5). Filter B classified 27% of circular culverts, 29% of box culverts, 20% of pipe arches, and 50% of fords as impassable (Figure E6). Filter C classified 38% of circular culverts, 35% of box culverts, 20% of pipe arches, and 100% of fords as impassable (Figure E7). The mean crossing width to channel width ratio (excluding fords, vented fords, and multiple structure crossings) was 0.99 ± 0.49 (mean ± SD) (n=30), and 11 crossings were greater than or equal to the bankfull channel width (Figure E8). The mean crossing width to channel width ratio for surveyed crossings classified impassable by Filter A was 0.60 ± 0.08 (n=4). The mean ratio for crossings classified impassable by Filter B was 0.84 ±0.41 (n=13), and was 0.83 ± 0.39 (n=17) for Filter C (Figure E9). The mean crossing width to channel width ratio for surveyed crossings classified passable by Filter A was 01.26 ± 0.56 (n=15). The mean ratio for crossings classified passable by Filter B was 1.35 ±0.61 (n=8), and was 1.48 ± 0.53 (n=7) for Filter C (Figure E9).

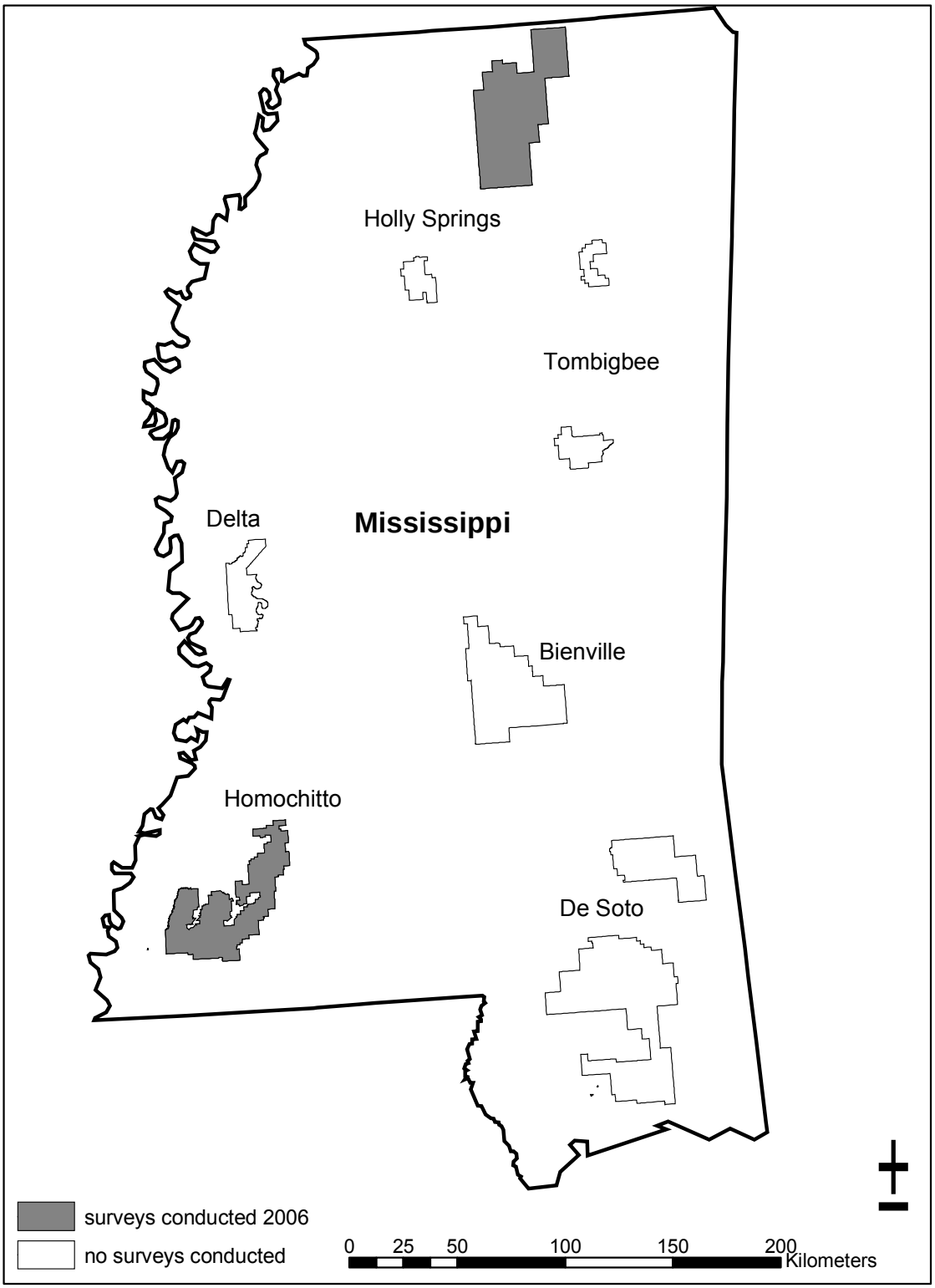

Figure E1. Ranger Districts on the National Forests in Mississippi road-stream crossing surveys were conducted, summer 2006.

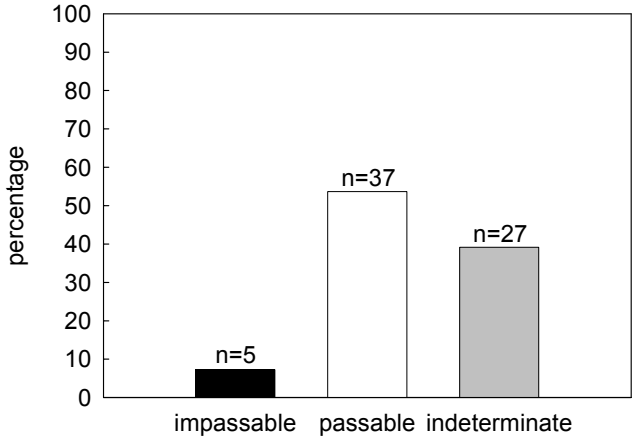

Figure E2. Percentage of crossings classified as impassable, passable, or indeterminate for Filter A; National Forests in Mississippi, summer 2006 (N=69).

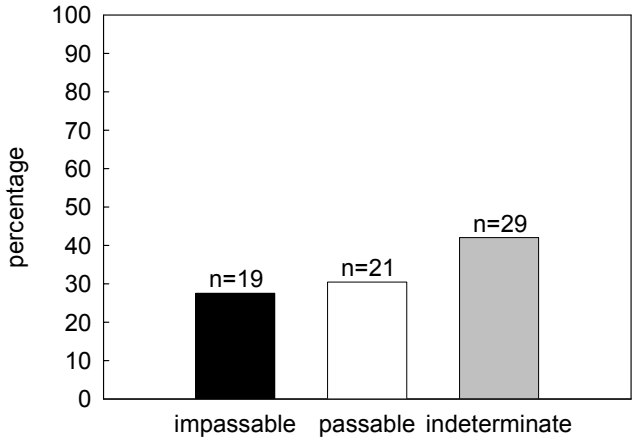

Figure E3. Percentage of crossings classified as impassable, passable, or indeterminate for Filter B; National Forests in Mississippi, summer 2006 (N=69).

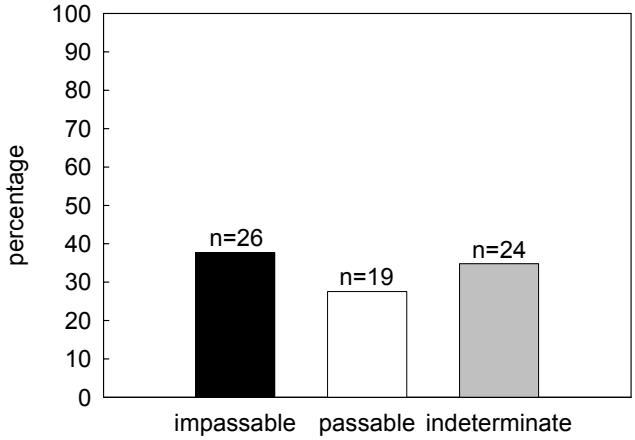

Figure E4. Percentage of crossings classified as impassable, passable, or indeterminate for Filter C; National Forests in Mississippi, summer 2006 (N=69).

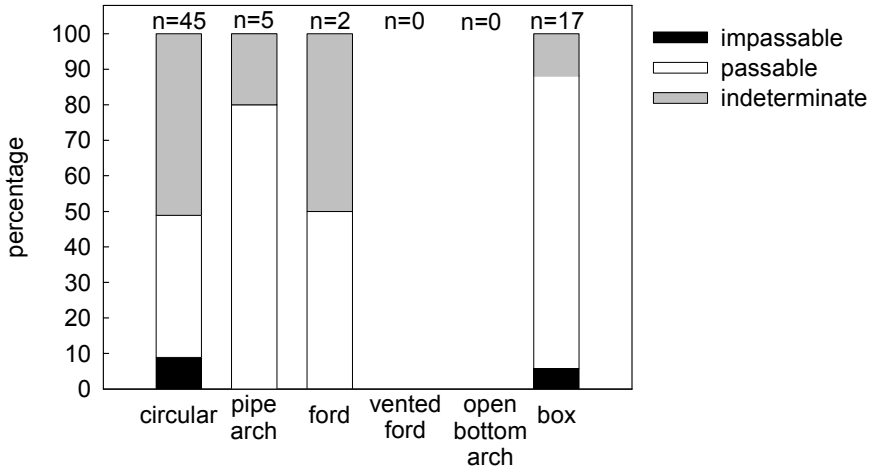

Figure E5. Percentage of each crossing type classified as impassable, passable, or indeterminate for Filter A; National Forests in Mississippi, summer 2006 (N=69).

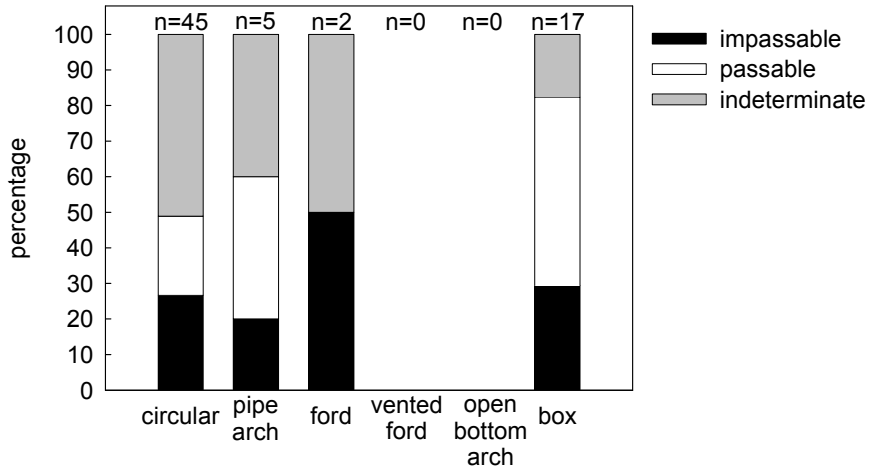

Figure E6. Percentage of each crossing type classified as impassable, passable, or indeterminate for Filter B; National Forests in Mississippi, summer 2006 (N=69).

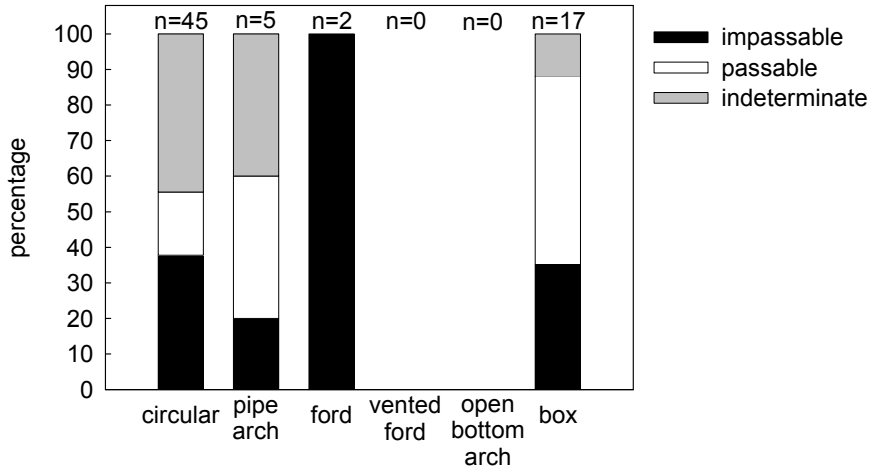

Figure E7. Percentage of each crossing type classified as impassable, passable, or indeterminate for Filter C; National Forests in Mississippi, summer 2006 (N=69).

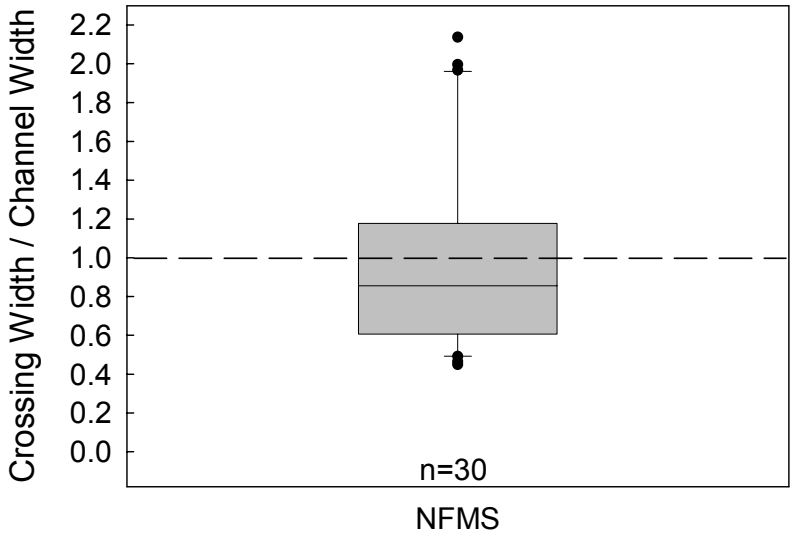

Figure E8. Crossing width to bankfull channel width ratio for crossings surveyed in summer 2006 on the National Forests in Mississippi (excluding fords, vented fords, and multiple structure crossings). A ratio of 1.0 (dashed line) or greater indicates the crossing structure opening is greater than or equal to the bankfull channel width. The top and bottom of the boxes represent the 25th and 75th percentiles, the bar in the center of each box represents the median, whiskers represent the 10th and 90th percentiles, and closed circles represent the entire range of the data.

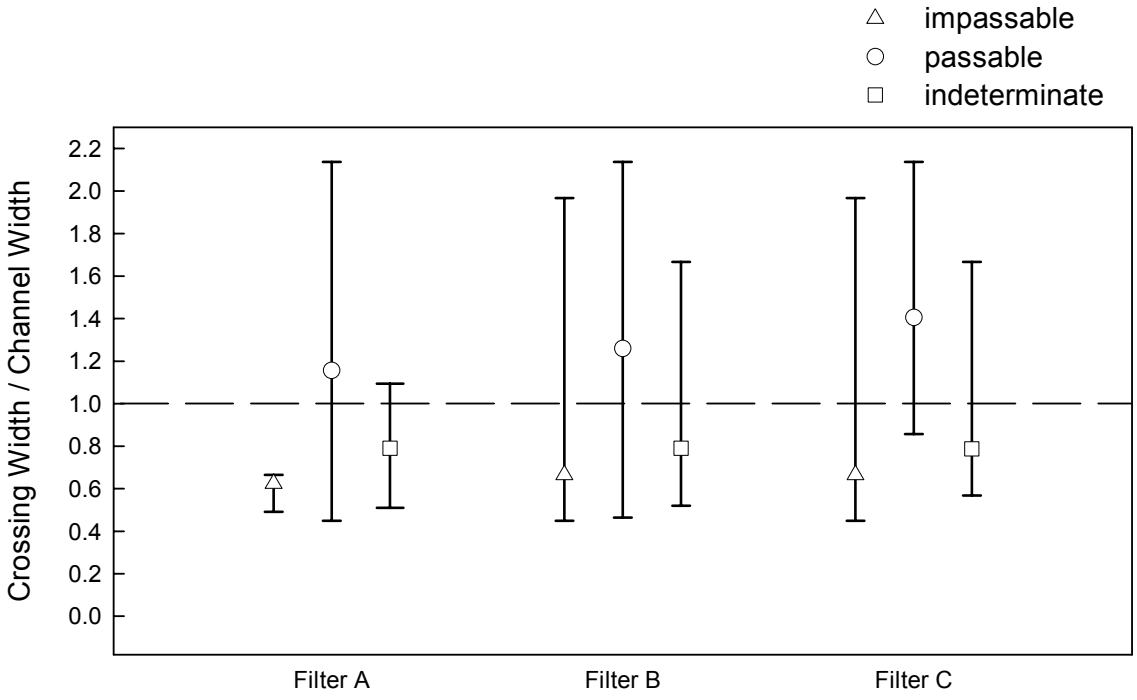

Figure E9. Crossing width to bankfull channel width ratio for crossings classified impassable, passable, or indeterminatein summer 2006 on the National Forests in Mississippi (excluding fords, vented fords, and multiple structure crossings). A ratio of 1.0 (dashed line) or greater indicates the crossing structure opening is greater than or equal to the bankfull channel width. The symbol inside each set of whiskers represents the median, and the top and bottom of the whiskers represent the maximum and minimum values.

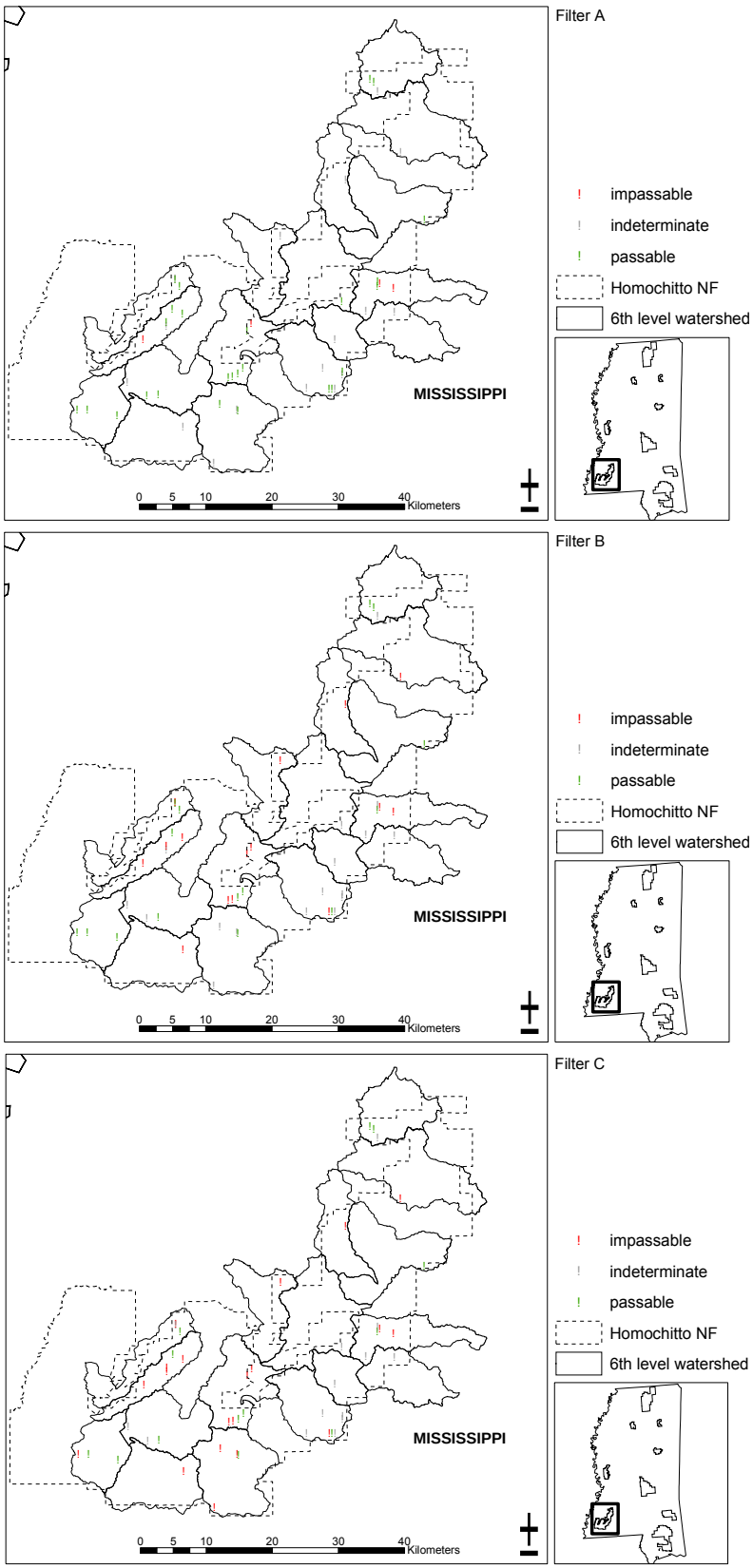

Figure E10. Location of crossings classified for fish passage by coarse filters A, B, and C within 6th level watersheds (draft) on the Homochitto National Forest, summer 2006.

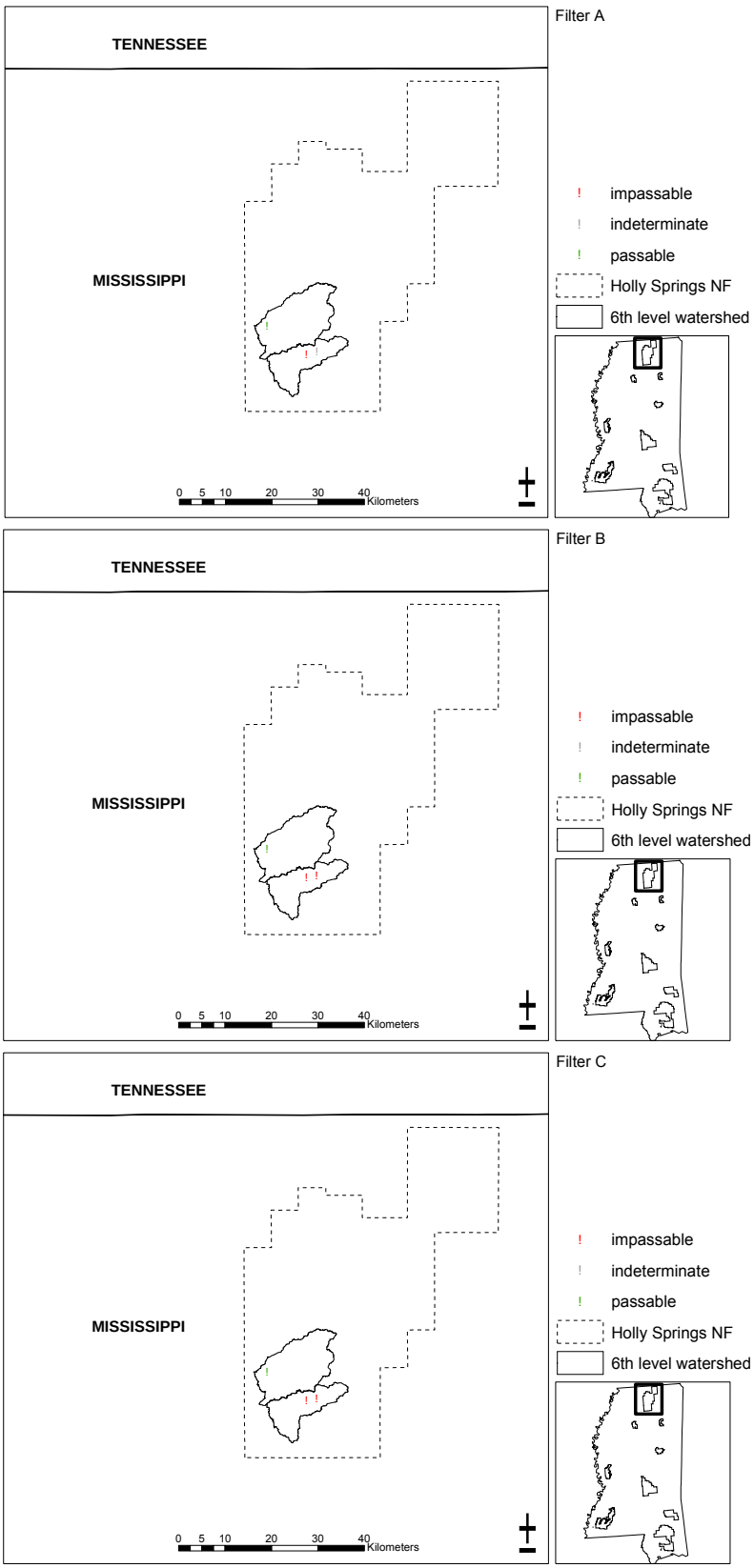

Figure E11. Location of crossings classified for fish passage by coarse filters A, B, and C within 6th level watersheds (draft) on the Holly Springs National Forest, summer 2006.

Table E1. Number of crossings documented (Total crossings documented) and not surveyed (Crossings not surveyed) on the National Forests in Mississippi summer 2006. Reasons for not surveying a documented site include: no suitable fish habitat upstream of crossing (NH); no access to site due to closed roads or private gates (NA); crossing was a natural ford (NF); crossing was a bridge (BR).

Forest	Total crossings documented	Crossings not surveyed (n, [%])				
		NH	NA	NF	BR	Total not surveyed
NFMS	96	14 (52)	1 (4)	11 (40)	1 (4)	27 (28)

Table E2. Number of crossings surveyed (Total surveyed) with coarse filter results for the National Forests in Mississippi summer 2006. Coarse filter results are presented for Filter A, Filter B, and Filter C (see filter descriptions, Fig 3 – 5).

Forest	Total surveyed	Coarse filter results								
		Impassable (n, [%])			Passable (n, [%])			Indeterminate (n, [%])		
		A	B	C	A	B	C	A	B	C
NFMS	69	5 (7)	19 (28)	26 (38)	37 (54)	21 (30)	19 (27)	27 (39)	29 (42)	24 (35)

Table E3. Location of crossings surveyed on the National Forests in Mississippi, summer of 2006. Site ID consists of the Forest abbreviation (HNF), road the crossing is on (101), and the distance (miles) from the junction road (0.5).

Site ID	# of Pipes	Forest #	District	Junction Road	Stream Name	Quad	6th Level Watershed
HNF128A-0.9	1	210	Homochitto	552	Foster Creek	Union Church	080602030601
HNF128A-1.4	1	208	Homochitto	552	UT Foster Creek	Union Church	080602030601
HNF128B-0.8	1	211	Homochitto	128A	Pierce Branch	Union Church	080602030601
HNF135A-0.5	2	256	Homochitto	115	UT Homochitto River	Caseyville	080602050102
HNF112A-0.6	2	270	Homochitto	112	UT Molls Creek	McCall Creek	080602050104
HNF113C-0.3	1	195	Homochitto	113	UT Fifteen Mile Creek	Eddicetown	080602050105
HNF145B-0.01	3	276	Homochitto	108	UT Homochitto River	Bude	080602050106
HNF199B-0.3	2	291	Homochitto	199	UT Porter Creek	Bude	080602050107
HNF196E-0.6	2	302	Homochitto	196B	UT Cane Mill Branch	Little Springs	080602050302
HNF145F-1.6	1	279	Homochitto	145	UT McGehee Creek	Bude	080602050303
HNF147-0.001	1	281	Homochitto	196B	UT McGehee Creek	Bude	080602050303
HNF147-0.4	1	284	Homochitto	196B	UT McGehee Creek	Bude	080602050303
HNF147G-2.3	1	294	Homochitto	Horse Creek Rd	UT McGehee Creek	Little Springs	080602050303
HNFplsvl-1.7	1	282	Homochitto	196	UT McGehee Creek	Bude	080602050303
HNF110C-1.5	2	--	Homochitto	110	UT Middle Fk Homochitto R	Kirby	080602050403
HNF118-0.7	1	24	Homochitto	165	Gresham Branch	Homochitto	080602050501
HNF118-1.3	1	25	Homochitto	165	Sulfur Springs Branch	Homochitto	080602050501
HNF118-1.9	1	26	Homochitto	165	UT Homochitto River	Homochitto	080602050501
HNF118-2.2	1	27	Homochitto	165	UT Homochitto River	Homochitto	080602050501
HNFC103-3.7	2	95	Homochitto	84	Quarterlot Branch	Meadville	080602050501
HNFC103-4.4	1	96	Homochitto	84	King Branch	Meadville	080602050501
HNF107LJ-0.4	1	11	Homochitto	107	UT Middleton Creek	Busy Corner	080602050502
HNF153A-1.2	3	9	Homochitto	153	Tanyard Creek	Busy Corner	080602050502
HNF153A-1.5	1	10	Homochitto	153	UT Tanyard Creek	Busy Corner	080602050502
HNF153A1-0.3	2	8	Homochitto	153	UT Tanyard Creek	Busy Corner	080602050502
HNF153B-0.7	1	7	Homochitto	153	UT Middleton Creek	Busy Corner	080602050502
HNF153B-1.0	2	6	Homochitto	153	UT Middleton Creek	Busy Corner	080602050502
HNF153D-0.9	2	4	Homochitto	153	UT Middleton Creek	Busy Corner	080602050502
HNF156E-1.3	1	--	Homochitto	156	UT Red Branch	Bewelcome	080602050504
HNF160-0.1	1	49	Homochitto	106	UT Birdman Branch	Homochitto	080602050504
HNF160-0.2	1	48	Homochitto	106	UT Walker Creek	Homochitto	080602050504

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Site ID	# of Pipes	Forest #	District	Junction Road	Stream Name	Quad	6th Level Watershed
HNFCR118-1.5	1	35	Homochitto	118	UT Homochitto River	Homochitto	080602050504
HNF191B-2.1	1	71	Homochitto	33	UT Homochitto River	Crosby	080602050505
HNF191B-3.1	1	68	Homochitto	33	UT Homochitto River	Crosby	080602050505
HNF196-0.9	2	78	Homochitto	33	UT Zeigler Creek	Crosby	080602050505
HNF122-0.3	1	61	Homochitto	33	UT Foster Creek	Crosby	080602050507
HNF193-2.4	3	136	Homochitto	127	Cahal Creek	Garden City	080602050601
HNF193-3.3	1	134	Homochitto	127	Turkey Creek	Garden City	080602050601
HNFkng-0.4	2	75	Homochitto	127	UT Dry Creek	Crosby	080602050601
HNF101-0.5	1	154	Homochitto	101	Wearly Branch	Knoxville	080602050602
HNF101-3.1	1	159	Homochitto	182	Rocky Branch	Knoxville	080602050602
HNF101C-0.2	1	158	Homochitto	101	Rocky Branch	Knoxville	080602050602
HNF102D-0.7	1	164	Homochitto	101	Dry Creek	Knoxville	080602050602
HNF184-0.1	2	161	Homochitto	101	Rocky Branch	Knoxville	080602050602
HNF101A-0.7	2	165	Homochitto	101	UT Tony Creek	Knoxville	080602050605
HNF101A-1.8	2	167	Homochitto	101	UT Tony Creek	Knoxville	080602050605
HNF190A-0.01	1	168	Homochitto	101	UT Tony Creek	Knoxville	080602050605
HSNF216-0.5	1	--	Holly Springs	245	UT Cypress Creek	Puskus Lake	080302010505
HNF246-0.1	1	--	Holly Springs	216	UT Puskus Creek	Puskus Lake	080302010505
HSNF244-0.4	2	--	Holly Springs	T4	Bagley Creek	Malone	080302010507

Table E4. Coarse filters A, B, and C, classifications for surveyed crossings on the National Forest in Mississippi, summer 2006.

Site ID	Pipe #	Forest #	Filter A	Filter B	Filter C
HNF128A-0.9	1	210	passable	passable	passable
HNF128A-1.4	1	208	passable	passable	passable
HNF128B-0.8	1	211	indeterminate	indeterminate	indeterminate
HNF135A-0.5	2	256	indeterminate	impassable	impassable
HNF112A-0.6	1	270	passable	passable	passable
HNF112A-0.6	2	270	passable	passable	passable
HNF113C-0.3	1	195	indeterminate	impassable	impassable
HNF145B-0.01	1	276	passable	indeterminate	indeterminate
HNF145B-0.01	2	276	passable	indeterminate	indeterminate
HNF145B-0.01	3	276	passable	indeterminate	indeterminate
HNF199B-0.3	1	291	indeterminate	indeterminate	indeterminate
HNF199B-0.3	2	291	indeterminate	indeterminate	indeterminate
HNF196E-0.6	1	302	indeterminate	indeterminate	indeterminate
HNF196E-0.6	2	302	indeterminate	indeterminate	indeterminate
HNF145F-1.6	1	279	indeterminate	indeterminate	indeterminate
HNF147-0.001	1	281	passable	indeterminate	indeterminate
HNF147-0.4	1	284	passable	passable	passable
HNF147G-2.3	1	294	impassable	impassable	impassable
HNFplsvl-1.7	1	282	impassable	impassable	impassable
HNF110C-1.5	1	--	indeterminate	impassable	impassable
HNF110C-1.5	2	--	indeterminate	impassable	impassable
HNF118-0.7	1	24	passable	passable	passable
HNF118-1.3	1	25	passable	passable	passable
HNF118-1.9	1	26	passable	impassable	impassable
HNF118-2.2	1	27	passable	impassable	impassable
HNFC103-3.7	2	95	impassable	impassable	impassable
HNFC103-4.4	1	96	passable	impassable	impassable
HNF107lJ-0.4	1	11	indeterminate	indeterminate	indeterminate
HNF153A-1.2	1	9	indeterminate	indeterminate	indeterminate
HNF153A-1.2	2	9	passable	passable	passable
HNF153A-1.2	3	9	passable	passable	passable
HNF153A-1.5	1	10	passable	impassable	impassable
HNF153A1-0.3	1	8	indeterminate	indeterminate	indeterminate
HNF153A1-0.3	2	8	indeterminate	indeterminate	indeterminate
HNF153B-0.7	1	7	indeterminate	indeterminate	indeterminate
HNF153B-1.0	1	6	passable	indeterminate	indeterminate
HNF153B-1.0	2	6	indeterminate	indeterminate	indeterminate
HNF153D-0.9	1	4	indeterminate	indeterminate	indeterminate
HNF153D-0.9	2	4	indeterminate	indeterminate	indeterminate
HNF156E-1.3	1	--	indeterminate	indeterminate	impassable
HNF160-0.1	1	49	indeterminate	indeterminate	impassable
HNF160-0.2	1	48	passable	passable	passable
HNFCR118-1.5	1	35	passable	indeterminate	impassable
HNF191B-2.1	1	71	passable	indeterminate	indeterminate
HNF191B-3.1	1	68	passable	passable	passable

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Site ID	Pipe #	Forest #	Filter A	Filter B	Filter C
HNF196-0.9	1	78	indeterminate	impassable	impassable
HNF196-0.9	2	78	indeterminate	indeterminate	indeterminate
HNF122-0.3	1	61	indeterminate	impassable	impassable
HNF193-2.4	1	136	indeterminate	indeterminate	impassable
HNF193-2.4	2	136	passable	indeterminate	indeterminate
HNF193-2.4	3	136	passable	passable	passable
HNF193-3.3	1	134	passable	passable	impassable
HNFkng-0.4	1	75	passable	passable	passable
HNFkng-0.4	2	75	passable	passable	passable
HNF101-0.5	1	154	impassable	impassable	impassable
HNF101-3.1	1	159	passable	impassable	impassable
HNF101C-0.2	1	158	indeterminate	indeterminate	impassable
HNF102D-0.7	1	164	passable	impassable	impassable
HNF184-0.1	1	161	passable	indeterminate	indeterminate
HNF184-0.1	2	161	passable	passable	passable
HNF101A-0.7	1	165	passable	passable	passable
HNF101A-0.7	2	165	passable	passable	passable
HNF101A-1.8	1	167	passable	passable	impassable
HNF101A-1.8	2	167	passable	indeterminate	indeterminate
HNF190A-0.01	1	168	indeterminate	impassable	impassable
HSNF216-0.5	1	--	indeterminate	impassable	impassable
HSNF244-0.4	1	--	passable	passable	passable
HSNF244-0.4	2	--	passable	passable	passable
HSNF246-0.1	1	--	impassable	impassable	impassable

Table E5. Description of crossings surveyed on the National Forests in Mississippi summer 2006. Shape abbreviations: C= circular, PA= pipe arch, OBA= open bottom arch, and F= ford. Channel width is the mean bankfull channel width. N= no natural substrate, N (discontin)= discontinuous substrate, Y= continuous natural substrate. An NA (not applicable) indicates outlet drop (no outlet pool or tailwater control) or outlet perch (stream dry) could not be calculated. Negative outlet drop or perch values indicate a submerged outlet (structure partially backwatered). Residual inlet depth values ≥ 0.0 indicate the structure is fully backwatered.

Site ID	Pipe #	Forest #	Shape	Pipe Condition	Mean Chnl Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width : Chnl Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
HNF128A-0.9	1	210	B	good	6.3	Y	1.07	1.90	0.00	-0.12	0.00	43.5	46.5
HNF128A-1.4	1	208	B	good	10.8	Y	1.91	1.11	-0.24	NA	0.00	43.0	82.0
HNF128B-0.8	1	211	B	good	12.2	N (discontin)	1.22	0.90	-3.18	-3.30	0.00	44.4	54.0
HNF135A-0.5	2	256	C	good	10.9	N	2.38	0.51	15.72	15.72	0.00	40.8	97.0
HNF112A-0.6	1	270	C	fair	10.3	N	0.58	0.49	-3.36	1.32	6.60	46.4	27.0
HNF112A-0.6	2	270	C	fair	10.3	N	0.84	0.49	-11.50	-11.90	6.84	46.5	39.0
HNF113C-0.3	1	195	C	fair	7.2	N	0.71	1.04	12.72	10.92	0.00	80.6	57.0
HNF145B-0.01	1	276	C	good	10.2	N	0.83	0.54	NA	NA	0.00	57.5	47.5
HNF145B-0.01	2	276	C	good	10.2	N	0.88	0.54	NA	NA	0.00	56.9	50.0
HNF145B-0.01	3	276	C	good	10.2	N	0.83	0.54	NA	NA	0.00	57.0	47.5
HNF199B-0.3	1	291	C	poor	10.0	N (discontin)	1.24	0.70	0.60	0.00	0.00	62.2	77.0
HNF199B-0.3	2	291	C	poor	10.0	N (discontin)	1.68	0.70	2.64	9.72	0.00	61.8	104.0
HNF196E-0.6	1	302	C	good	10.1	N	1.23	0.64	-1.32	2.70	0.00	49.3	60.5
HNF196E-0.6	2	302	C	good	10.1	N	1.08	0.64	0.78	2.94	0.00	48.7	52.5
HNF145F-1.6	1	279	C	fair	9.5	N (discontin)	2.63	0.79	-9.48	-4.92	0.00	55.8	147.0
HNF147-0.001	1	281	B	good	6.0	N (discontin)	0.28	1.67	-2.64	-4.56	0.00	119.3	33.0
HNF147-0.4	1	284	PA	good	6.9	N (discontin)	0.25	0.95	-1.08	-4.74	0.00	36.2	9.0
HNF147G-2.3	1	294	C	poor	7.5	N	0.55	0.67	34.38	13.62	0.00	30.1	16.5
HNFplsvl-1.7	1	282	C	fair	4.9	N	5.74	0.62	46.56	54.48	0.00	40.0	229.5

Table continued next page…

Site ID	Pipe #	Forest #	Shape	Pipe Condition	Mean Chnl Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width : Chnl Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
HNF110C-1.5	1	--	C	good	11.2	N	3.50	0.53	14.16	2.28	0.00	76.9	269.0
HNF110C-1.5	2	--	C	good	11.2	N	3.71	0.53	13.44	11.88	0.00	77.1	286.0
HNF118-0.7	1	24	B	good	9.8	Y	0.18	1.41	1.26	NA	0.90	101.0	18.0
HNF118-1.3	1	25	B	good	8.8	Y	0.26	2.00	NA	1.44	0.00	123.7	32.5
HNF118-1.9	1	26	B	good	8.1	N	0.77	1.24	11.88	9.48	0.00	58.8	45.0
HNF118-2.2	1	27	B	good	6.1	N	0.76	1.97	10.32	14.16	0.00	60.7	46.0
HNFC103-3.7	2	95	B	poor	13.1	N (discontin)	0.71	0.76	33.54	21.60	0.00	63.6	45.0
HNFC103-4.4	1	96	B	good	15.0	N (discontin)	0.44	0.67	21.06	18.84	0.00	68.2	30.0
HNF107lJ-0.4	1	11	C	good	9.9	N (discontin)	2.17	0.57	NA	-2.04	0.00	48.4	105.0
HNF153A-1.2	1	9	C	good	19.0	N	0.96	0.29	0.48	NA	0.00	60.7	58.0
HNF153A-1.2	2	9	C	good	19.0	N	0.23	0.29	3.60	NA	0.00	60.7	14.0
HNF153A-1.2	3	9	C	good	19.0	N	0.12	0.29	3.36	NA	0.00	60.7	7.0
HNF153A-1.5	1	10	PA	fair	8.5	N (discontin)	0.17	0.86	11.16	10.80	0.00	30.0	5.0
HNF153A1-0.3	1	8	C	poor	10.5	N	1.46	0.57	3.84	1.56	0.00	59.2	88.0
HNF153A1-0.3	2	8	C	poor	10.5	N	1.93	0.57	3.84	-0.24	0.00	59.5	115.0
HNF153B-0.7	1	7	PA	fair	8.9	N	1.75	0.79	0.84	-0.24	0.00	54.2	95.0
HNF153B-1.0	1	6	C	good	23.8	N (discontin)	0.96	0.21	NA	0.48	0.00	49.1	47.0
HNF153B-1.0	2	6	C	good	23.8	N (discontin)	1.15	0.21	NA	-0.48	0.00	48.8	56.0
HNF153D-0.9	1	4	C	poor	13.0	N (discontin)	2.25	0.50	-2.64	-6.48	0.00	37.7	85.0
HNF153D-0.9	2	4	C	poor	13.0	N	3.17	0.50	-0.48	-4.20	0.00	38.2	121.0
HNF156E-1.3	1	--	C	good	5.5	N	2.35	1.09	5.16	3.84	0.00	82.4	194.0
HNF160-0.1	1	49	C	good	7.3	N	1.50	0.52	6.12	3.48	0.00	40.0	60.0
HNF160-0.2	1	48	C	poor	7.5	Y	2.55	0.86	-2.46	9.48	0.00	40.2	102.5
HNFCR118-1.5	1	35	B	good	6.9	N (discontin)	0.50	1.16	9.36	7.56	0.00	84.5	42.0
HNF191B-2.1	1	71	C	fair	9.4	N	0.70	0.75	0.24	1.68	0.00	40.2	28.0

Table continued next page…

Site ID	Pipe #	Forest #	Shape	Pipe Condition	Mean Chnl Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width : Chnl Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
HNF191B-3.1	1	68	B	good	6.6	Y	0.23	2.14	3.30	0.60	0.00	76.8	17.5
HNF196-0.9	1	78	C	poor	4.9	N	3.66	0.62	-2.10	1.50	0.00	22.7	83.0
HNF196-0.9	2	78	C	poor	4.9	N	3.49	0.37	-6.12	-1.62	0.00	19.5	68.0
HNF122-0.3	1	61	B	good	5.1	N	1.75	0.99	17.58	15.18	0.00	45.4	79.5
HNF193-2.4	1	136	C	good	8.2	N	0.68	0.73	NA	3.48	0.00	88.5	60.0
HNF193-2.4	2	136	C	good	8.2	N	0.43	0.73	NA	0.24	0.00	88.5	38.0
HNF193-2.4	3	136	C	good	8.2	N	0.09	0.73	NA	-1.91	0.00	88.5	8.0
HNF193-3.3	1	134	C	good	16.6	N	0.23	0.46	7.80	9.00	0.00	70.8	16.0
HNFkng-0.4	1	75	B	good	21.2	Y	0.46	0.76	7.62	4.32	0.00	88.7	41.0
HNFkng-0.4	2	75	B	good	21.2	Y	0.48	0.76	7.62	4.32	0.00	87.9	42.0
HNF101-0.5	1	154	C	fair	9.5	N	0.37	0.63	51.54	19.38	0.00	49.9	18.5
HNF101-3.1	1	159	C	good	17.8	N	0.71	0.45	12.96	8.28	0.00	45.0	32.0
HNF101C-0.2	1	158	F	poor	20.4	N (discontin)	1.24	0.00	4.44	-4.44	0.00	58.8	73.0
HNF102D-0.7	1	164	F	good	25.4	N	1.41	0.00	10.32	9.12	0.00	14.9	21.0
HNF184-0.1	1	161	PA	good	29.1	N (discontin)	0.66	0.24	0.84	2.28	0.00	41.1	27.0
HNF184-0.1	2	161	PA	good	29.1	Y	0.49	0.24	0.24	-0.24	0.00	40.6	20.0
HNF101A-0.7	1	165	C	good	7.4	N (discontin)	2.26	0.87	4.62	3.78	9.06	50.5	114.0
HNF101A-0.7	2	165	C	good	7.4	N	4.27	0.87	5.76	-1.92	20.10	50.5	215.5
HNF101A-1.8	1	167	C	fair	6.6	N (discontin)	0.04	0.83	4.86	4.86	0.00	45.3	2.0
HNF101A-1.8	2	167	C	fair	6.6	N (discontin)	1.12	0.83	-0.24	7.98	0.00	44.7	50.0
HNF190A-0.01	1	168	C	good	8.4	N	3.32	0.83	23.94	22.14	0.00	48.4	160.5
HSNF-216-0.5	1	--	C	fair	8.6	N	3.93	0.58	23.88	24.54	0.00	40.0	157.0
HSNF244-0.4	1	--	B	good	17.5	N	0.87	0.23	-26.60	-30.70	31.92	50.9	44.5
HSNF244-0.4	2	--	B	good	17.5	N	0.73	0.23	-37.90	-42.0	33.48	50.9	37.0
HSNF246-0.1	1	--	C	poor	17.1	N	0.85	0.49	32.10	29.58	0.00	30.7	26.0

Appendix F: Results for the National Forests in Texas

We completed surveys at 92 (73%) of 126 documented crossing structures on the Angelina, Sabine, and Davy Crockett National Forests in 2006 (Figure F1, Tables F1 and F2). Filter A (strong swimmers and leapers) classified 11% (n=10) of crossings as impassable, 63% (n=58) as passable, and 26% (n=24) as indeterminate (Figure F2, Table F2). Filter B (moderate swimmers and leapers) classified 30% (n=28) of crossings as impassable, 45% (n=41) as passable, and 25% (n=23) as indeterminate (Figure F3, Table F2). Filter C (weak swimmers and leapers) classified 50% (n=46) of crossing as impassable, 32% (n=29) as passable, and 18% (n=17) as indeterminate (Figure F4, Table F2). Characteristics and filter classifications for each crossing are presented in Tables F3-F5.

The majority of the crossings surveyed were circular culverts (64%, n=59), while box culverts (21%, n=19), pipe arches (11%, n=10), vented fords (4%, n=4), fords (0%, n=0), and open bottom arches (0%, n=0) were less frequently encountered or not encountered. Filter A classified 5% of circular culverts, 26% of box culverts, 20% of pipe arches, and 0% of vented fords as impassable (Figure F5). Filter B classified 22% of circular culverts, 58% of box culverts, 40% of pipe arches, and 0% of vented fords as impassable (Figure F6). Filter C classified 44% of circular culverts, 74% of box culverts, 60% of pipe arches, and 0% of vented fords as impassable (Figure F7). The mean crossing width to channel width ratio (excluding fords, vented fords, and multiple structure crossings) was 0.85 ± 0.30 (mean ± SD) (n=62), and 15 crossings were greater than or equal to the bankfull channel width (Figure F8). The mean crossing width to channel width ratio for surveyed crossings classified impassable by Filter A was 0.97 ± 0.37 (n=8). The mean ratio for crossings classified impassable by Filter B was 0.88 ± 0.39 (n=21), and was 0.87 ± 0.34 (n=33) for Filter C (Figure F9). The mean crossing width to channel width ratio for surveyed crossings classified passable by Filter A was 0.85 ± 0.26 (n=35). The mean ratio for crossings classified passable by Filter B was 0.83 ± 0.23 (n=23), and was 0.79 ± 0.21 (n=16) for Filter C (Figure F9).

Figure F1. National Forests in Texas where road-stream crossing surveys were conducted, summer 2006.

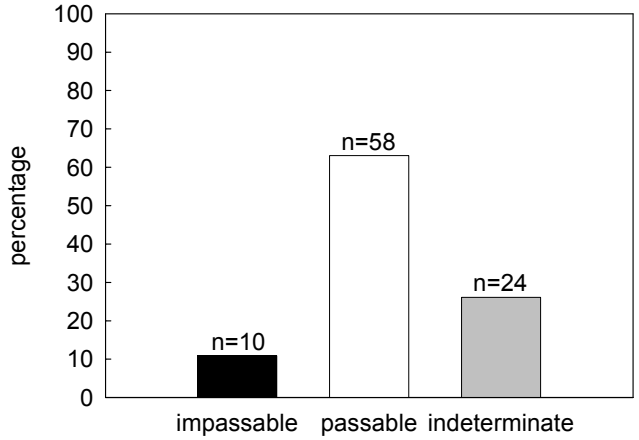

Figure F2. Percentage of crossings classified as impassable, passable, or indeterminate for Filter A; National Forests in Texas, summer 2006 (N=92).

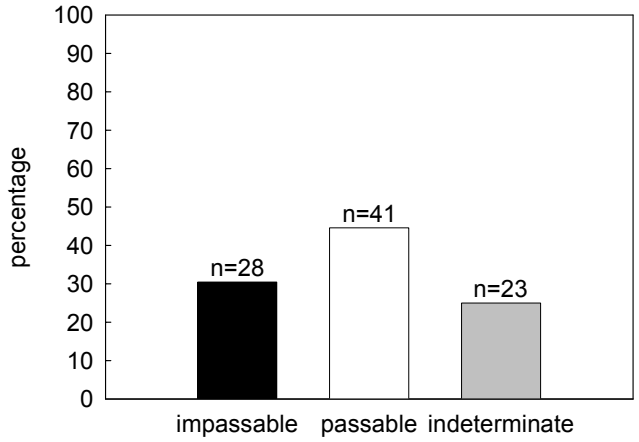

Figure F3. Percentage of crossings classified as impassable, passable, or indeterminate for Filter B; National Forests in Texas, summer 2006 (N=92).

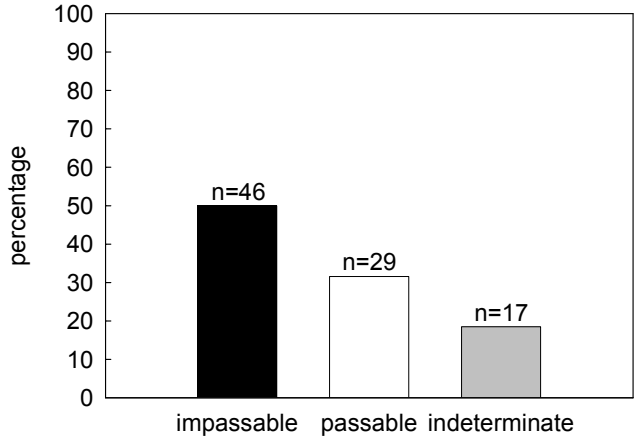

Figure F4. Percentage of crossings classified as impassable, passable, or indeterminate for Filter C; National Forests in Texas, summer 2006 (N=92).

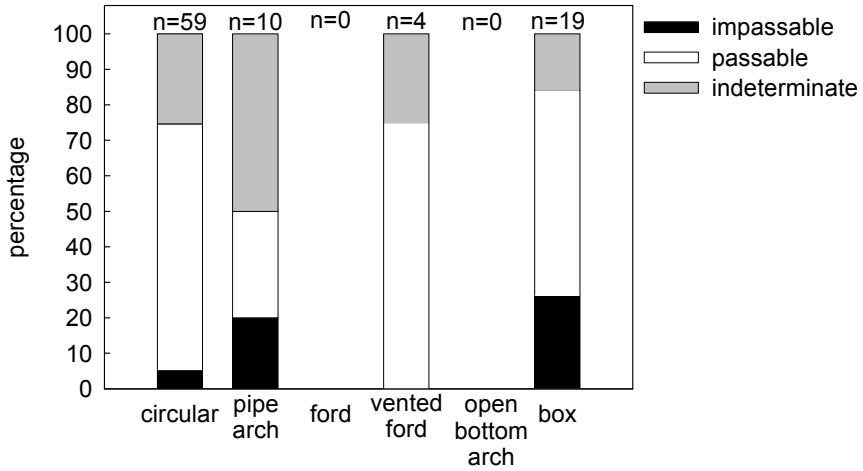

Figure F5. Percentage of each crossing type classified as impassable, passable, or indeterminate for Filter A; National Forests in Texas, summer 2006 (N=92).

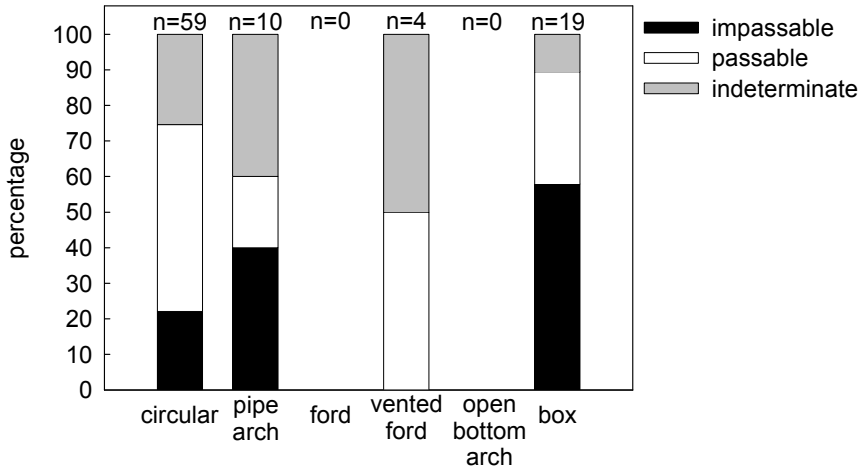

Figure F6. Percentage of each crossing type classified as impassable, passable, or indeterminate for Filter B; National Forests in Texas, summer 2006 (N=92).

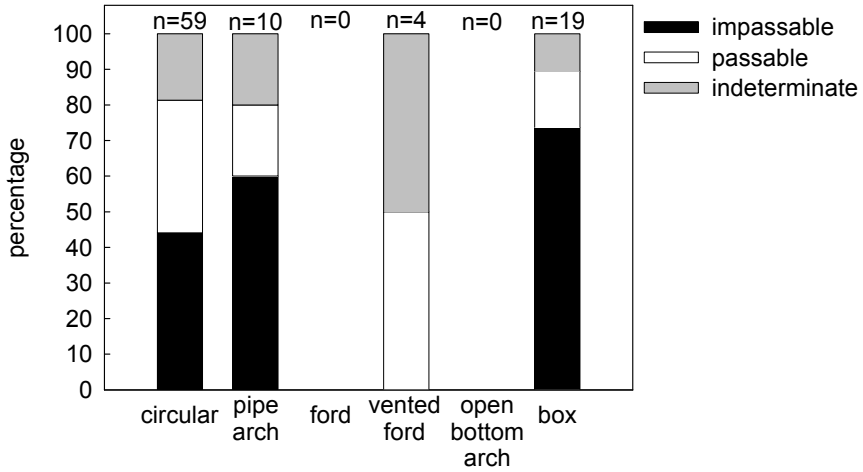

Figure F7. Percentage of each crossing type classified as impassable, passable, or indeterminate for Filter C; National Forests in Texas, summer 2006 (N=92).

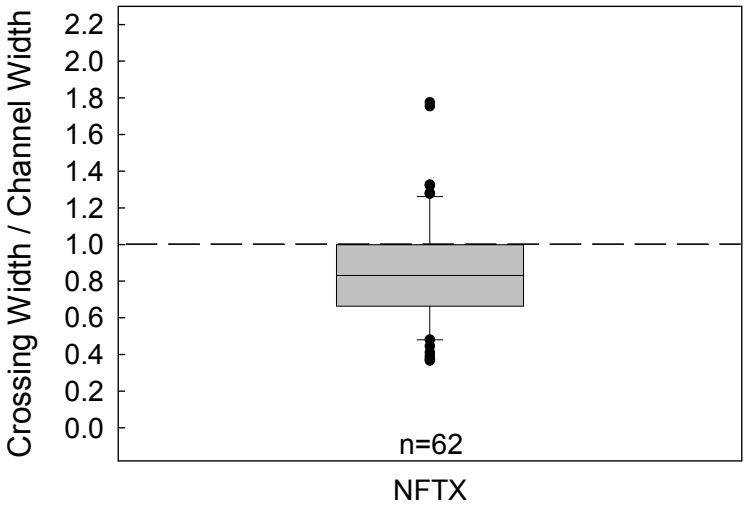

Figure F8. Crossing width to bankfull channel width ratio for crossings surveyed in summer 2006 on the National Forests in Texas (excluding fords, vented fords, and multiple structure crossings). A ratio of 1.0 (dashed line) or greater indicates the crossing structure opening is greater than or equal to the bankfull channel width. The top and bottom of the boxes represent the 25th and 75th percentiles, the bar in the center of each box represents the median, whiskers represent the 10th and 90th percentiles, and closed circles represent the entire range of the data.

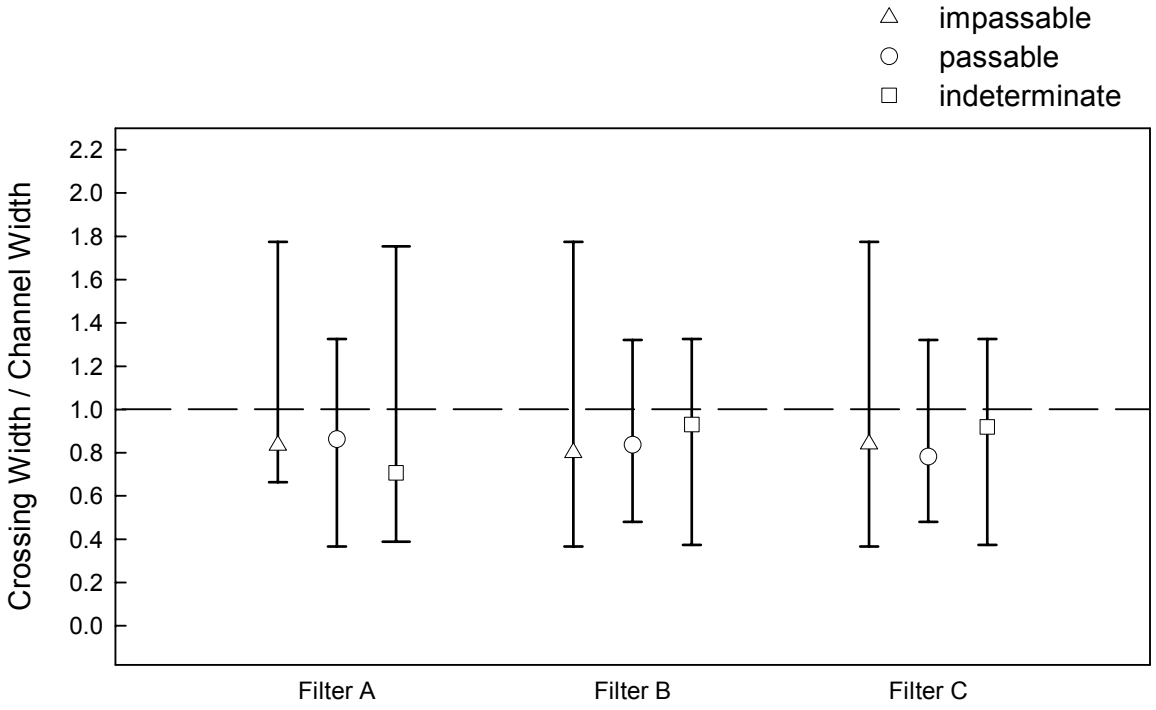

Figure F9. Crossing width to bankfull channel width ratio for crossings classified impassable, passable, or indeterminate in summer 2006 on the National Forests in Texas (excluding fords, vented fords, and multiple structure crossings). A ratio of 1.0 (dashed line) or greater indicates the crossing structure opening is greater than or equal to the bankfull channel width. The symbol inside each set of whiskers represents the median, and the top and bottom of the whiskers represent the maximum and minimum values.

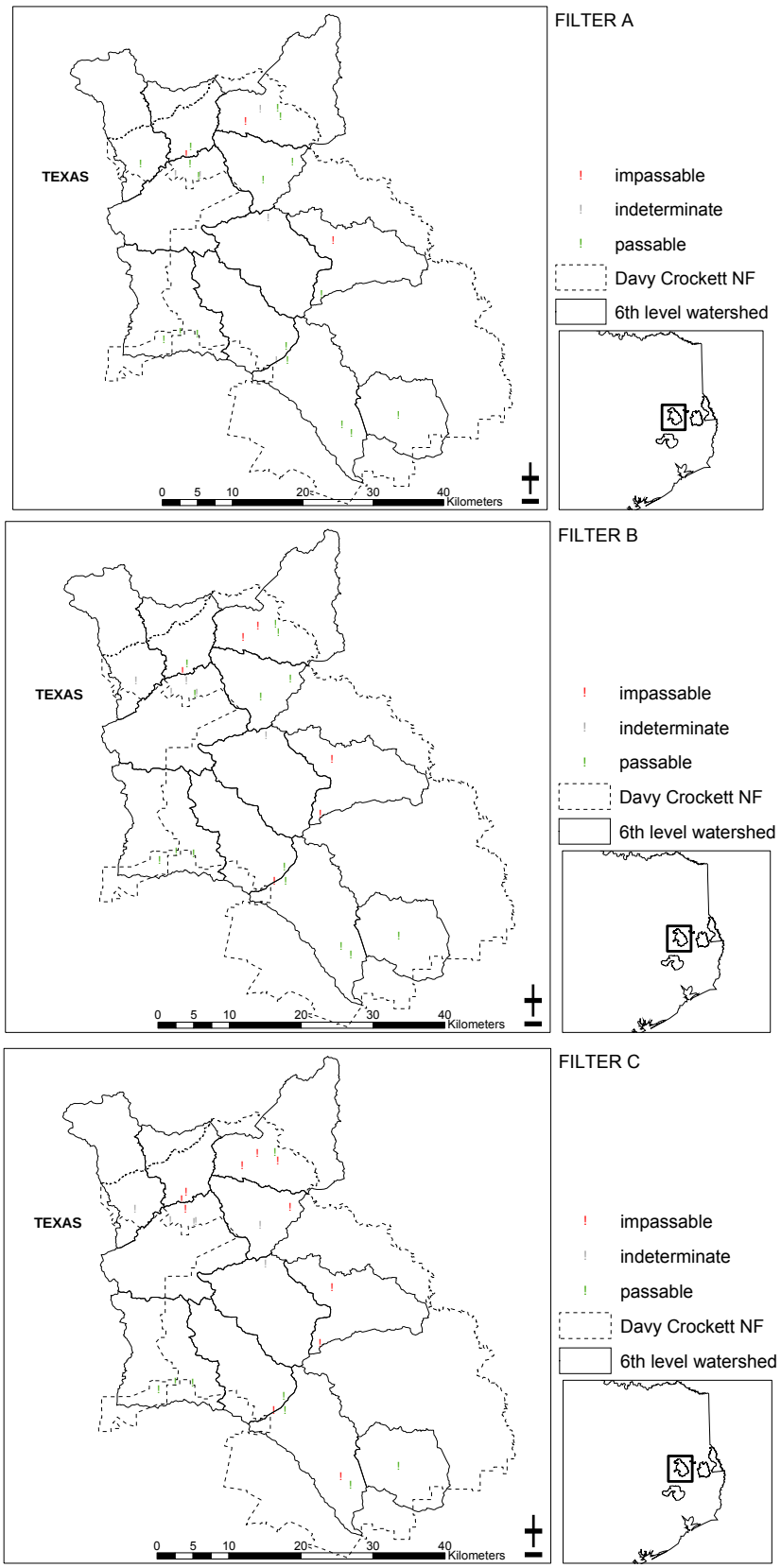

Figure F10. Location of crossings classified for fish passage by coarse filters A, B, and C within 6th level watersheds (draft) on the Davy Crockett National Forest, summer 2006.

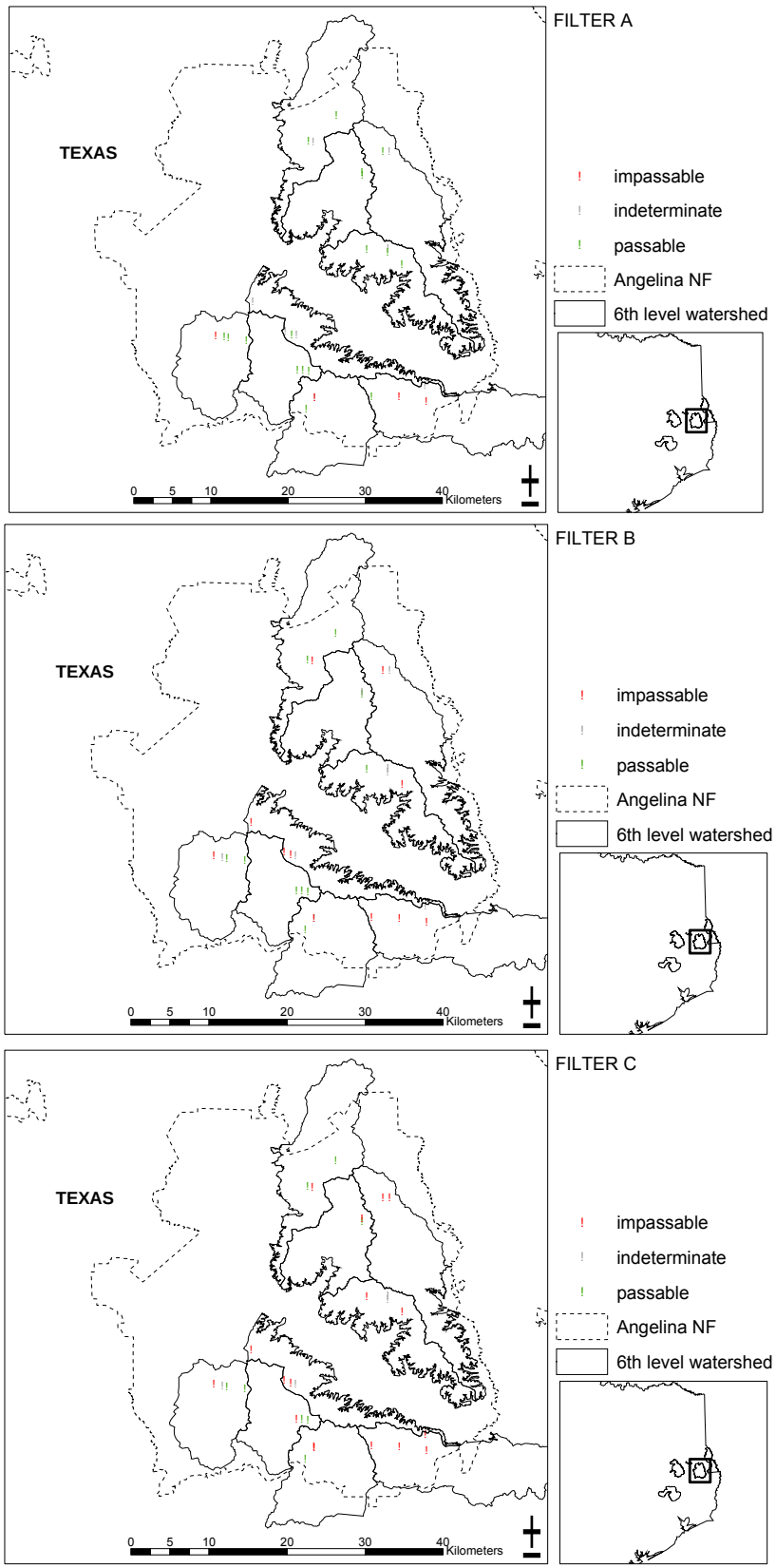

Figure F11. Location of crossings classified for fish passage by coarse filters A, B, and C within 6th level watersheds (draft) on the Angelina National Forest, summer 2006.

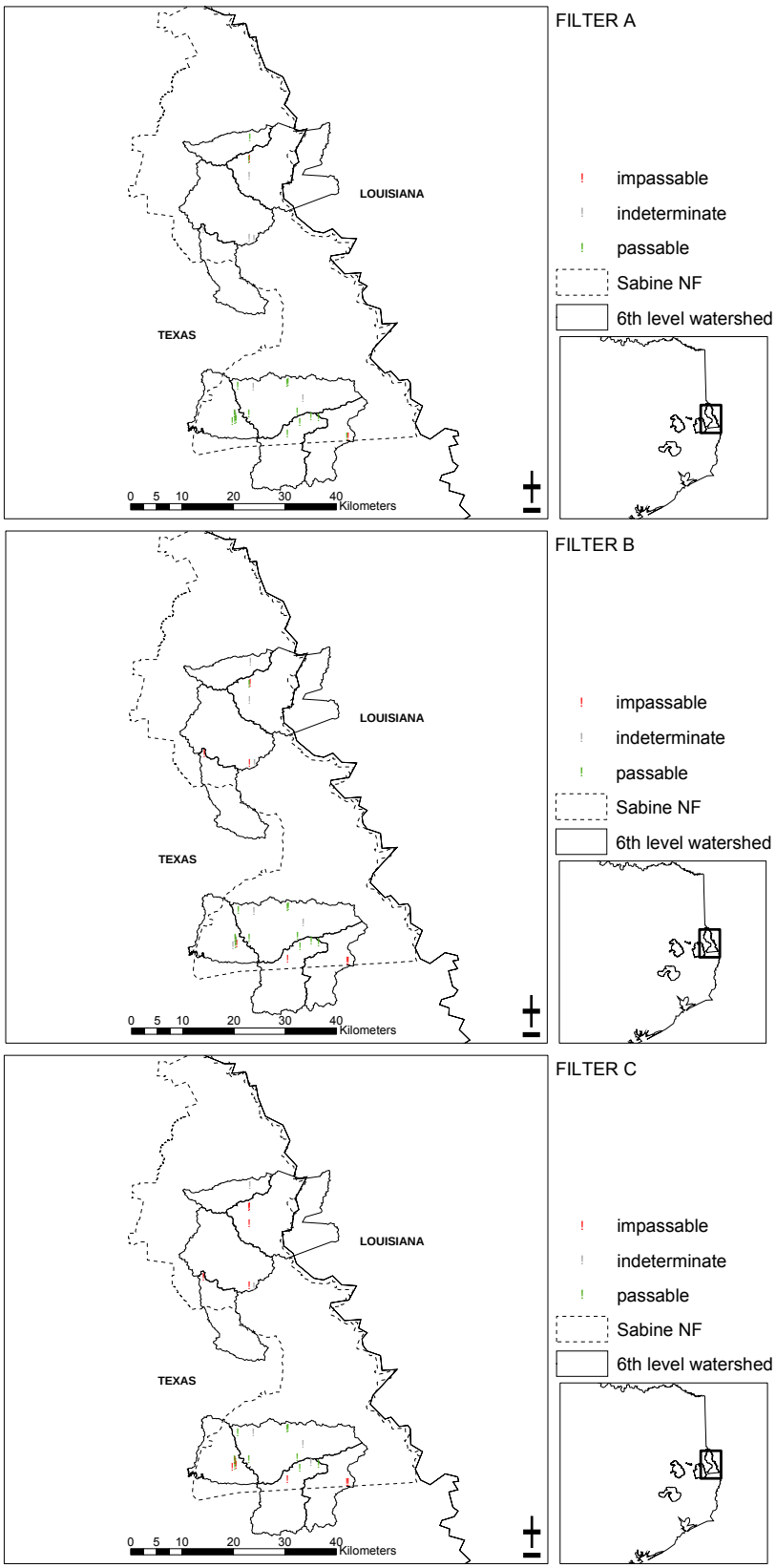

Figure F12. Location of crossings classified for fish passage by coarse filters A, B, and C within 6th level watersheds (draft) on the Sabine National Forest, summer 2006.

Table F1. Number of crossings documented (Total crossings documented) and not surveyed (Crossings not surveyed) on the National Forests in Texas (Angelina, Sabine, and Davy Crockett NFs), summer 2006. Reasons for not surveying a documented site include: no suitable fish habitat upstream of crossing (NH); no access to site due to closed roads or private gates (NA); crossing was a natural ford (NF); crossing was a bridge (BR).

Forest	Total crossings documented	Crossings not surveyed (n, [%])				
		NH	NA	NF	BR	Total not surveyed
NFTX	126	31 (91)	1 (3)	1 (3)	1 (3)	34 (27)

Table F2. Number of crossings surveyed (Total surveyed) with coarse filter results for the National Forests in Texas (Angelina, Sabine, and Davy Crockett NFs), summer 2006. Coarse filter results are presented for Filter A, Filter B, and Filter C (see filter descriptions, Fig 3 – 5).

Forest	Total surveyed	Coarse filter results								
		Impassable (n, [%])			Passable (n, [%])			Indeterminate (n, [%])		
		A	B	C	A	B	C	A	B	C
NFTX	92	10 (11)	28 (30)	46 (50)	58 (63)	41 (45)	29 (32)	24 (26)	23 (25)	17 (18)

Table F3. Location of crossings surveyed on the National Forests in Texas, summer of 2006. Site ID consists of the Forest abbreviation (ANF), road the crossing is on (300A), and the distance (miles) from the junction road (1.6).

Site ID	Pipe #	District	Junction Road	Stream Name	Quad	6th Level Watershed
ANF3053-0.8	1	Angelina	4-4	UT Cypress Creek	Zavalla	120200030102
ANF4-4-0.2	1	Angelina	paved to gravel	Mill Creek	Zavalla	120200030102
ANF4-4-1.1	1	Angelina	paved to gravel	Cypress Creek	Cassells-Boykin Park	120200030102
ANF4-4-2.3	1	Angelina	paved to gravel	Oil Well Creek	Cassells-Boykin Park	120200030102
ANF302-1.5	1	Angelina	303	UT holly branch	Boykin Spring	120200030104
ANF302-1.9	1	Angelina	303	UT Holly Branch	Boykin Spring	120200030104
ANF302-2.3	1	Angelina	303	UT White Oak Branch	Boykin Spring	120200030104
ANF313-2-0.1	1	Angelina	313	UT Boykin Creek	Boykin Spring	120200030105
ANF313-2-0.15	1	Angelina	313	UT Boykin Creek	Boykin Spring	120200030105
ANF326A-0.7	2	Angelina	326	Boykin Creek	Boykin Spring	120200030105
ANF300W-3.1	1	Angelina	147	UT Prairie Creek	Broaddus	120200050309
ANF300W-3.4	1	Angelina	147	Prairie Creek	Broaddus	120200050309
ANF301-0.4	1	Angelina	147	Running Branch	Norwood	120200050309
ANF307-1.3	1	Angelina	300E	UT Sandy Creek	Harvey Creek	120200050601
ANF307-1.7	1	Angelina	300E	Wash Branch	Harvey Creek	120200050601
ANF300A-1.6	1	Angelina	300E	Franklin Branch	Harvey Creek	120200050701
ANF300A-1.8	1	Angelina	300E	UT Franklin Branch	Harvey Creek	120200050701
ANF308-1.4	1	Angelina	2743	Julia Creek	Cassells-Boykin Park	120200050702
ANF354-0.4	1	Angelina	ANG4-4	Caney Creek	Cassells-Boykin Park	120200050702
ANF354-0.9	1	Angelina	ANG4-4	UT Caney Creek	Cassells-Boykin Park	120200050702
ANF354-1.2	1	Angelina	ANG4-4	UT Caney Creek	Cassells-Boykin Park	120200050702
ANF304E-1.7	1	Angelina	705	Blackland Branch	Veach	120200050703
ANF304E-3.4	1	Angelina	705	UT Beach Basin	Veach	120200050703
ANF3094-0.1	1	Angelina	304E	UT Beach Basin	Veach	120200050703
ANF317-1.4	1	Angelina	304E	Parker Creek	Veach	120200050703
ANF332-0.2	1	Angelina	335	UT Wards Branch	Ebenezer	120200050801
ANF333-0.2	2	Angelina	63	Buck Branch	Ebenezer	120200050801
ANF333A-2.0	1	Angelina	333	Trout Creek	Ebenezer	120200050801
ANF335-0.2	2	Angelina	63	UT Wards Branch	Ebenezer	120200050801
DCNF1560A-1.1	1	Davy Crockett	1560	Austin Branch	Crockett NE	120200010705
DCNF524-1.0	1	Davy Crockett	21	Johnson Creek	Crockett NE	120200010706

Table continued next page…

Site ID	Pipe #	District	Junction Road	Stream Name	Quad	6th Level Watershed
DCNF5261-0.2	1	Davy Crockett	526A	UT Spur Creek	Crockett NE	120200010706
DCNF511-0.1	2	Davy Crockett	526	Bluff Creek	Weches	120200020101
DCNF511-0.7	2	Davy Crockett	526	Camp Creek	Weches	120200020101
DCNF526-3.0	1	Davy Crockett	FM 227	Pole Branch	Weches	120200020101
DCNF526-4.5	1	Davy Crockett	FM 227	UT Camp Creek	Weches	120200020101
DCNF524-0.5	2	Davy Crockett	526	Johnson Creek	Crockett NE	120200020102
DCNF5241-0.5	2	Davy Crockett	524A	Gum Creek	Crockett NE	120200020102
DCNF524B-0.8	1	Davy Crockett	524	Johnson Creek	Crockett NE	120200020102
DCNF524B-1.0	1	Davy Crockett	524	Johnson Creek	Crockett NE	120200020102
DCNF511-4.2	2	Davy Crockett	526	Walnut Creek	Ratcliff	120200020103
DCNF556-1.1	1	Davy Crockett	1170	Hickory Creek	Ratcliff	120200020103
DCNF521-1.2	1	Davy Crockett	227	UT Lee Creek	Ratcliff	120200020202
DCNF4740-1.7	1	Davy Crockett	7	Brushy Creek	Kennard NE	120200020203
DCNF527-4.4	1	Davy Crockett	525	Garrison Creek	Centralia	120200020203
DCNF589-0.3	2	Davy Crockett	568	UT Alabama Creek	Apple Springs	120200020304
DCNF502-2.4	2	Davy Crockett	357	UT Piney Creek	Pennington	120200020401
DCNF570-0.5	2	Davy Crockett	3154	UT Piney Creek	Pennington	120200020401
DCNF502-3.4	2	Davy Crockett	357	UT Piney Creek	Pennington	120200020402
DCNF523-1.9	1	Davy Crockett	528	UT Piney Creek	Groveton East	120200020402
DCNF528B-1.1	1	Davy Crockett	528	UT Piney Creek	Groveton East	120200020402
DCNF508B-1.1	2	Davy Crockett	508	E Fork White Rock Creek	Berea	120302020701
DCNF587-0.4	2	Davy Crockett	508	Tanyard Creek	Fodice	120302020701
DCNF587-1.9	2	Davy Crockett	508	Big Branch	Fodice	120302020701
SBNF156-0.9	2	Sabine	1384	North Blue Bayou	Patroon North	120100040502
SBNF126-1.3	1	Sabine	2261	UT Brittain Creek	Patroon North	120100040505
SBNF126-3.3	1	Sabine	2261	UT Sanders Creek	Patroon North	120100040505
SBNF126-3.4	1	Sabine	2261	Sanders Creek	Patroon North	120100040505
SBNF131A-0.9	1	Sabine	131	UT Bourghs Creek	Patroon South	120100040702
SBNF131A-1.5	1	Sabine	131	UT Bourghs Creek	Patroon South	120100040702
SBNF108-1.8	1	Sabine	Boggy Creek Rd	El Labanillo Creek	Patroon South	120100040902
SBNF114A-1.5	1	Sabine	114	UT Sixmile Creek	Pineland South	120100041101
SBNF109-0.3	1	Sabine	87	UT Conner Creek	Hemphill	120100041101

Table continued next page…

Site ID	Pipe #	District	Junction Road	Stream Name	Quad	6th Level Watershed
SBNF109-0.5	1	Sabine	87	Conner Creek	Hemphill	120100041101
SBNF111-2.7	2	Sabine	87	UT Sixmile Creek	Hurricane Creek	120100041101
SBNF152-1.1	1	Sabine	2426	Pigeon Creek	Pineland North	120100041101
SBNF152-4.0	1	Sabine	2426	Sixmile Creek	Pineland North	120100041101
SBNF175-0.4	1	Sabine	111A	UT Toledo Bend Reservoir	Hurricane Creek	120100041101
SBNF117-0.9	1	Sabine	144	UT Hyden Branch	Hurricane Creek	120100041102
SBNF111B-0.2	1	Sabine	111	UT Big Sandy Creek	Hurricane Creek	120100041102
SBNF144A-0.2	2	Sabine	144	UT Big Sandy Creek	Hurricane Creek	120100041102
SBNF144B-0.3	2	Sabine	144	UT Big Sandy Creek	Hurricane Creek	120100041102
SBNF113-0.8	1	Sabine	87	UT Shingle Branch	Fairmount	120100041103
SBNF113-0.9	1	Sabine	87	UT Shingle Branch	Fairmount	120100041103
SBNF114-2.5	1	Sabine	2426	UT Little Creek	Pineland South	120200050604
SBNF114-2.8	1	Sabine	2426	Little Creek	Pineland South	120200050604
SBNF114B-0.1	1	Sabine	114	UT Little Creek	Pineland South	120200050604
SBNF114B-0.4	1	Sabine	114	UT Little Creek	Pineland South	120200050604
SBNF114-0.1	1	Sabine	114A	UT Curry Creek	Pineland South	120200050604
SBNF114-0.2	1	Sabine	114A	UT Curry Creek	Pineland South	120200050604

Table F4. Coarse filters A, B, and C, classifications for surveyed crossings on the National Forest in Texas, summer 2006.

Site ID	Pipe #	Filter A	Filter B	Filter C
ANF3053-0.8	1	passable	indeterminate	indeterminate
ANF4-4-0.2	1	impassable	impassable	impassable
ANF4-4-1.1	1	passable	passable	passable
ANF4-4-2.3	1	passable	passable	passable
ANF302-1.5	1	passable	passable	impassable
ANF302-1.9	1	passable	passable	passable
ANF302-2.3	1	passable	passable	passable
ANF313-2-0.1	1	impassable	impassable	impassable
ANF313-2-0.15	1	indeterminate	indeterminate	impassable
ANF326A-0.7	1	passable	passable	passable
ANF326A-0.7	2	passable	passable	passable
ANF300W-3.1	1	indeterminate	impassable	impassable
ANF300W-3.4	1	passable	passable	passable
ANF301-0.4	1	passable	passable	passable
ANF307-1.3	1	passable	impassable	impassable
ANF307-1.7	1	indeterminate	indeterminate	impassable
ANF300A-1.6	1	passable	indeterminate	impassable
ANF300A-1.8	1	passable	passable	passable
ANF308-1.4	1	indeterminate	impassable	impassable
ANF354-0.4	1	indeterminate	impassable	impassable
ANF354-0.9	1	passable	impassable	impassable
ANF354-1.2	1	indeterminate	indeterminate	indeterminate
ANF304E-1.7	1	passable	impassable	impassable
ANF304E-3.4	1	indeterminate	indeterminate	indeterminate
ANF3094-0.1	1	passable	indeterminate	indeterminate
ANF317-1.4	1	passable	passable	impassable
ANF332-0.2	1	indeterminate	indeterminate	impassable
ANF333-0.2	1	passable	impassable	impassable
ANF333-0.2	2	passable	impassable	impassable
ANF333A-2.0	1	impassable	impassable	impassable
ANF335-0.2	1	impassable	impassable	impassable
ANF335-0.2	2	impassable	impassable	impassable
DCNF1560A-1.1	1	passable	indeterminate	indeterminate
DCNF524-1.0	1	impassable	impassable	impassable
DCNF5261-0.2	1	passable	passable	impassable
DCNF511-0.1	2	passable	passable	passable
DCNF511-0.7	1	passable	passable	impassable
DCNF511-0.7	2	passable	passable	impassable
DCNF526-3.0	1	impassable	impassable	impassable
DCNF526-4.5	1	indeterminate	impassable	impassable
DCNF524-0.5	2	passable	indeterminate	impassable
DCNF5241-0.5	1	indeterminate	indeterminate	indeterminate
DCNF524B-0.8	1	passable	passable	indeterminate
DCNF524B-1.0	1	indeterminate	indeterminate	indeterminate
DCNF511-4.2	1	passable	passable	impassable
DCNF511-4.2	2	passable	passable	impassable

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Site ID	Pipe #	Filter A	Filter B	Filter C
DCNF556-1.1	1	passable	passable	indeterminate
DCNF521-1.2	1	indeterminate	indeterminate	indeterminate
DCNF4740-1.7	1	impassable	impassable	impassable
DCNF527-4.4	1	passable	impassable	impassable
DCNF589-0.3	2	passable	passable	passable
DCNF502-2.4	2	passable	passable	passable
DCNF570-0.5	1	indeterminate	impassable	impassable
DCNF570-0.5	2	indeterminate	impassable	impassable
DCNF502-3.4	1	passable	passable	passable
DCNF502-3.4	2	passable	passable	passable
DCNF523-1.9	1	passable	passable	impassable
DCNF528B-1.1	1	passable	passable	passable
DCNF508B-1.1	2	passable	passable	passable
DCNF587-0.4	1	indeterminate	impassable	impassable
DCNF587-0.4	2	passable	passable	passable
DCNF587-1.9	2	passable	passable	passable
SBNF156-0.9	1	indeterminate	indeterminate	indeterminate
SBNF156-0.9	2	passable	indeterminate	indeterminate
SBNF126-1.3	1	indeterminate	indeterminate	impassable
SBNF126-3.3	1	passable	passable	impassable
SBNF126-3.4	1	impassable	impassable	impassable
SBNF131A-0.9	1	indeterminate	impassable	impassable
SBNF131A-1.5	1	indeterminate	indeterminate	indeterminate
SBNF108-1.8	1	indeterminate	impassable	impassable
SBNF109-0.3	1	passable	passable	passable
SBNF109-0.5	1	passable	passable	passable
SBNF111-2.7	1	passable	indeterminate	indeterminate
SBNF111-2.7	2	passable	passable	passable
SBNF114A-1.5	1	passable	passable	passable
SBNF152-1.1	1	indeterminate	indeterminate	indeterminate
SBNF152-4.0	1	passable	passable	passable
SBNF175-0.4	1	indeterminate	indeterminate	indeterminate
SBNF111B-0.2	1	passable	passable	passable
SBNF117-0.9	1	passable	impassable	impassable
SBNF144A-0.2	1	passable	passable	passable
SBNF144A-0.2	2	passable	passable	passable
SBNF144B-0.3	1	passable	passable	indeterminate
SBNF144B-0.3	2	indeterminate	indeterminate	impassable
SBNF113-0.8	1	passable	impassable	impassable
SBNF113-0.9	1	impassable	impassable	impassable
SBNF114-0.1	1	indeterminate	indeterminate	impassable
SBNF114-0.2	1	passable	passable	passable
SBNF114-2.5	1	passable	passable	passable
SBNF114-2.8	1	passable	impassable	impassable
SBNF114B-0.1	1	passable	passable	passable
SBNF114B-0.4	1	passable	indeterminate	impassable

Table F5. Description of crossings surveyed on the National Forests in Texas, summer 2006. Shape abbreviations: C= circular, PA= pipe arch, OBA= open bottom arch, F= ford, and O= Other. Channel width is the mean bankfull channel width. N= no natural substrate, N (discontin)= discontinuous substrate, Y= continuous natural substrate. An NA (not applicable) indicates outlet drop (no outlet pool or tailwater control) or outlet perch (stream dry) could not be calculated. Negative outlet drop or perch values indicate a submerged outlet (structure partially backwatered). Residual inlet depth values ≥ 0.0 indicate the structure is fully backwatered.

Site ID	Pipe #	Shape	Pipe Condition	Mean Channel Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width: Channel Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
ANF3053-0.8	1	C	poor	7.0	N	1.19	0.37	0.24	2.52	0.00	25.3	30.0
ANF4-4-0.2	1	C	fair	9.8	N	0.34	0.66	25.80	15.84	0.00	32.1	11.0
ANF4-4-1.1	1	C	poor	9.1	N	0.66	0.52	-6.48	0.00	4.08	30.5	20.0
ANF4-4-2.3	1	PA	good	11.4	N	0.43	0.48	-5.34	-6.36	3.78	30.2	13.0
ANF302-1.5	1	C	good	6.4	N	0.35	1.08	9.12	10.80	0.00	47.9	17.0
ANF302-1.9	1	C	poor	4.9	N	0.67	0.80	-4.44	-3.66	0.60	48.0	32.0
ANF302-2.3	1	C	good	7.6	Y	0.05	1.32	NA	3.36	0.00	66.3	3.0
ANF313-2-0.1	1	PA	fair	5.0	N	2.78	1.23	29.40	27.96	0.00	70.6	196.0
ANF313-2-0.15	1	PA	poor	6.2	Y	1.54	0.99	5.40	4.20	0.00	79.3	122.0
ANF326A-0.7	1	VF	good	12.1	Y	0.19	0.41	-6.96	-6.48	6.12	37.1	7.0
ANF326A-0.7	2	VF	good	12.1	Y	0.77	0.41	-6.72	-6.24	3.30	37.1	28.5
ANF300W-3.1	1	PA	poor	6.2	N	6.63	0.49	8.22	-0.48	0.00	45.3	300.5
ANF300W-3.4	1	PA	good	7.3	Y	NA	NA	NA	NA	0.00	NA	NA
ANF301-0.4	1	C	fair	9.2	N	1.17	0.54	-7.20	-7.68	3.30	27.8	32.5
ANF307-1.3	1	B	good	11.6	N	1.00	0.79	18.78	14.94	0.00	41.6	41.5
ANF307-1.7	1	C	fair	7.5	N (discontin)	2.27	1.06	5.64	-0.18	0.00	56.5	128.0
ANF300A-1.6	1	C	poor	6.7	N (discontin)	0.81	0.95	7.68	NA	0.00	54.2	44.0
ANF300A-1.8	1	C	fair	5.1	N	0.07	0.95	0.30	-0.48	0.00	48.9	3.5
ANF308-1.4	1	B	fair	7.9	N	0.89	1.02	17.76	18.24	0.00	69.6	62.0
ANF354-0.4	1	C	fair	10.6	N	1.88	0.44	14.04	13.32	0.00	34.0	64.0
ANF354-0.9	1	C	poor	6.6	N	1.20	0.37	12.72	9.72	0.00	36.6	44.0

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Site ID	Pipe #	Shape	Pipe Condition	Mean Channel Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width: Channel Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
ANF354-1.2	1	PA	fair	7.1	N	1.58	0.71	-5.40	-9.00	0.00	49.3	78.0
ANF304E-1.7	1	C	poor	7.2	N	0.47	0.69	15.00	15.00	0.00	30.1	14.0
ANF304E-3.4	1	C	poor	6.8	N	1.52	0.81	3.48	5.52	0.00	33.6	51.0
ANF3094-0.1	1	C	fair	7.2	N	0.68	1.33	NA	0.00	0.00	47.4	32.0
ANF317-1.4	1	C	poor	7.2	N	0.29	0.98	4.56	3.72	0.00	55.9	16.0
ANF332-0.2	1	C	fair	4.0	N	2.20	1.00	4.32	0.60	0.00	40.5	89.0
ANF333-0.2	1	B	good	9.6	N	0.35	0.75	14.52	11.16	0.00	37.6	13.0
ANF333-0.2	2	B	good	9.6	N	0.03	0.75	15.96	12.60	0.00	37.5	1.0
ANF333A-2.0	1	B	good	11.7	N	0.00	0.86	38.76	37.68	0.00	50.2	0.0
ANF335-0.2	1	B	good	10.3	N	0.90	0.97	30.84	6.96	0.00	49.8	45.0
ANF335-0.2	2	B	good	10.3	N	0.98	0.97	30.24	10.56	0.00	49.8	49.0
DCNF1560A-1.1	1	C	good	9.6	N (discontin)	0.83	0.94	NA	-3.90	0.00	48.0	40.0
DCNF524-1.0	1	C	good	3.8	N	5.14	0.80	25.08	24.60	0.00	32.7	168.0
DCNF5261-0.2	1	C	poor	6.0	N	0.70	1.01	9.42	3.54	0.00	32.0	22.5
DCNF511-0.1	2	B	good	6.4	Y	1.31	1.53	3.42	NA	4.44	50.0	65.5
DCNF511-0.7	1	B	good	12.8	N (discontin)	0.10	0.70	4.92	0.90	0.00	25.7	2.5
DCNF511-0.7	2	B	good	12.8	N	0.11	0.70	4.86	1.20	0.00	26.1	3.0
DCNF526-3.0	1	B	poor	5.6	N	0.54	1.78	45.18	51.00	0.00	47.6	25.5
DCNF526-4.5	1	B	good	5.7	N	1.28	1.75	16.44	16.14	0.00	60.3	77.0
DCNF524-0.5	2	B	good	5.7	N (discontin)	0.76	1.76	6.66	6.90	0.00	38.6	29.5
DCNF5241-0.5	1	C	fair	5.9	N (discontin)	1.04	1.20	0.54	0.72	0.00	49.3	51.5
DCNF524B-0.8	1	B	good	6.3	N (discontin)	0.39	1.28	1.92	3.00	0.00	61.2	24.0
DCNF524B-1.0	1	B	good	8.4	N (discontin)	1.02	0.96	NA	-4.26	0.00	53.6	54.5
DCNF511-4.2	1	C	fair	9.5	N	0.12	0.49	4.98	2.04	0.00	40.1	5.0
DCNF511-4.2	2	C	fair	9.5	N	0.64	0.49	7.26	5.34	0.00	40.1	25.5
DCNF556-1.1	1	C	good	8.7	N (discontin)	0.49	0.92	-2.28	0.00	0.00	42.0	20.5

Table continued next page…

Site ID	Pipe #	Shape	Pipe Condition	Mean Channel Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width: Channel Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
DCNF521-1.2	1	C	good	7.4	N	1.41	0.68	1.68	0.36	0.00	38.3	54.0
DCNF4740-1.7	1	O	fair	10.1	N	0.07	0.84	35.22	33.36	0.00	44.5	3.0
DCNF527-4.4	1	B	good	9.1	N	0.15	1.09	20.82	20.52	0.00	65.9	10.0
DCNF589-0.3	2	C	poor	7.7	N (discontin)	0.34	0.78	-0.96	0.72	0.00	29.2	10.0
DCNF502-2.4	2	C	poor	10.1	Y	5.36	0.40	-5.76	0.60	0.00	26.5	142.0
DCNF570-0.5	1	C	fair	8.8	N	1.30	0.68	15.24	19.56	0.00	47.7	62.0
DCNF570-0.5	2	C	fair	8.8	N	1.06	0.68	16.32	20.64	0.00	51.0	54.0
DCNF502-3.4	1	C	fair	9.0	N (discontin)	3.05	0.48	3.12	8.64	10.92	38.4	117.0
DCNF502-3.4	2	C	fair	9.0	N (discontin)	0.18	0.53	-3.72	1.32	4.56	38.6	7.0
DCNF523-1.9	1	C	fair	9.5	N	0.21	0.48	6.48	5.52	0.00	48.6	10.0
DCNF528B-1.1	1	C	poor	8.3	Y	6.08	0.60	15.36	10.92	12.60	38.3	233.0
DCNF508B-1.1	2	C	poor	10.6	N (discontin)	0.03	0.47	-1.80	NA	1.68	39.3	1.00
DCNF587-0.4	1	C	poor	10.4	N (discontin)	1.78	0.77	11.16	3.30	0.00	40.1	71.5
DCNF587-0.4	2	C	poor	10.4	N (discontin)	0.25	0.77	1.14	0.84	0.00	33.9	8.5
DCNF587-1.9	2	C	fair	8.3	N (discontin)	0.91	0.97	-1.98	-1.32	6.30	39.4	36.0
SBNF156-0.9	1	VF	fair	NA	N	1.32	NA	NA	-7.80	0.00	40.5	53.5
SBNF156-0.9	2	VF	fair	NA	N	1.12	NA	NA	-7.80	0.00	40.5	45.5
SBNF126-1.3	1	C	fair	5.2	N	1.74	0.39	6.36	2.28	0.00	66.0	115
SBNF126-3.3	1	C	fair	6.0	N	0.13	0.66	8.22	12.00	0.00	43.5	5.5
SBNF126-3.4	1	B	poor	12.1	N	0.72	0.83	33.84	21.60	0.00	53.6	38.5
SBNF131A-0.9	1	C	fair	5.1	N	3.41	0.41	14.64	15.00	0.00	37.8	129.0
SBNF131A-1.5	1	C	fair	8.2	N	2.11	0.49	0.25	-0.83	0.00	40.2	85.0
SBNF108-1.8	1	C	poor	5.4	N	1.86	0.55	15.36	12.96	0.00	29.0	54.0
SBNF109-0.3	1	B	fair	7.3	Y	0.07	0.96	-1.20	-4.56	0.72	36.6	2.5
SBNF109-0.5	1	B	good	7.9	Y	0.09	0.76	NA	-0.24	0.00	75.5	7.0

Table continued next page…

Site ID	Pipe #	Shape	Pipe Condition	Mean Channel Width (ft)	Continuous Substrate in Structure	Pipe Slope (%)	Pipe Width: Channel Width ratio	Outlet Drop (in)	Outlet Perch (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
SBNF111-2.7	2	C	fair	9.4	N	0.14	0.53	0.72	-8.64	0.00	29.6	4.0
SBNF114A-1.5	1	C	fair	4.6	N	0.22	0.87	-0.84	-0.90	0.00	40.1	9.0
SBNF152-1.1	1	PA	fair	8.6	N	2.40	0.70	0.00	0.12	0.00	34.6	83.0
SBNF152-4.0	1	C	good	8.1	Y	1.01	0.86	-6.72	0.00	11.64	40.7	41.0
SBNF175-0.4	1	C	fair	8.7	N	1.35	0.92	-7.68	-7.92	0.00	48.2	65.0
SBNF111B-0.2	1	C	fair	4.2	N	0.51	0.84	-6.00	0.00	3.96	33.1	17.0
SBNF117-0.9	1	C	poor	4.7	N	0.61	1.28	10.86	12.96	0.00	39.5	28.5
SBNF144A-0.2	1	C	fair	9.2	N	0.69	0.82	-5.52	-5.52	1.68	46.1	32.0
SBNF144A-0.2	2	C	fair	9.2	N	0.11	0.82	-5.04	-5.04	4.44	46.1	5.0
SBNF144B-0.3	1	C	poor	12.5	N	0.51	0.53	0.12	2.28	0.00	46.9	24.0
SBNF144B-0.3	2	C	poor	12.5	N	1.39	0.53	5.52	6.36	0.00	46.1	64.0
SBNF113-0.8	1	C	fair	4.4	N	0.99	0.69	11.16	15.72	0.00	30.4	30.0
SBNF113-0.9	1	C	fair	6.7	N	1.04	0.75	27.96	27.60	0.00	34.6	36.0
SBNF114-0.1	1	PA	fair	6.9	N	2.36	0.51	6.84	6.36	0.00	25.4	60.0
SBNF114-0.2	1	C	good	7.2	N	0.40	0.70	-2.16	0.00	0.60	32.7	13.0
SBNF114-2.5	1	C	good	6.9	N	1.27	0.72	-6.06	0.00	10.98	32.2	41.0
SBNF114-2.8	1	PA	fair	9.2	N	0.97	1.09	11.22	-6.96	0.00	38.7	37.5
SBNF114B-0.1	1	C	fair	6.9	N	0.20	0.74	-4.32	0.00	5.04	30.3	6.0
SBNF114B-0.4	1	C	poor	6.3	N	0.77	1.04	4.20	9.48	0.00	43.1	33.0
SBNF111-2.7	2	C	fair	9.4	N	0.14	0.53	0.72	-8.64	0.00	29.6	4.0