Effects of Low Flow on *Amblema neislerii* in the Apalachicola River, Florida

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Introduction

Background. The Apalachicola River, formed by the confluence of the Flint and Chattahoochee Rivers, originates at Navigation Mile (NM) 106.3, just south of Lake Seminole in the tailwater of Jim Woodruff Lock and Dam. The river provides habitat for an endemic freshwater mussel species (family: Unionidae), the fat threeridge, *Amblema neislerii* (Lea, 1858), which was listed as endangered on 15 April 1998 (Federal Register Volume 63, Number 50, pages 12664-12687). Recent low rainfall in the southeast has caused conditions in the river to be less than optimal for aquatic life. Since 1999, with the exception of 2003 and 2005, average monthly minimum discharge at Jim Woodruff Dam for part of the year was less than 10,000 cubic feet per second (cfs). As specified in the 1989 draft Apalachicola, Chattahoochee, Flint Basin (ACF) water control plan, the Mobile District is required to maintain a minimum river flow of 5,000 cfs at Jim Woodruff Dam. More recently**,** the Jim Woodruff Dam Interim Operations Plan (IOP), developed as part of Section 7 Consultation with the USFWS, allows for a desired minimum flow of 6,500 cfs when conditions permit. When basin inflows are less than 5,000 cfs (or less than the desired 6,500 cfs under certain conditions specified in the IOP), storage from the upstream reservoirs is used to augment flows below Jim Woodruff Dam.

Because of extremely low water in 2007, plus the likelihood that water levels will remain low in 2008, the Mobile District is concerned that upstream storage used to augment flows could become depleted and the resulting discharges to the Apalachicola River could drop below 5,000 cfs. This lower discharge could negatively affect freshwater mussels, including *A. neislerii*. In the event all conservation storage is depleted, a precipitous drop in flows on the Apalachicola River could result, with flows essentially limited to inflows on the Flint basin (which has been estimated at 2,000 cfs or less in late summer and early fall of 2007). A controlled higher discharge below 5,000 cfs could potentially mitigate the amount of storage necessary for flow augmentation, prolong the length of time augmentation flows can be provided, and avoid a catastrophic loss of all conservation storage in the upstream reservoirs.

Purpose and Scope

The purpose of this report is to analyze the depth-distribution of *A. neislerii* in the Apalachicola River and to discuss the possible effects of discharge less than 5,000 cfs on this species. Data for this evaluation was taken from two studies: 1) a low flow mussel distribution study conducted in 2003 (Miller and Payne 2005), and 2) a similar survey conducted in the early summer of 2007 (Miller and Payne 2007).

Study Areas

2003 Studies. Mussels were collected at 11 sites in 2003 (Table 1). With the exception of the two sites in Chipola Cutoff, all others were at designated dredged material disposal areas rather than at optimal habitat locations.

2007 Studies. Study areas for the 2007 survey were chosen by personnel of the US Fish and Wildlife Service (USFWS). They identified 25 study areas between NM 40 and 50 which either supported, or appeared likely to support *A. neislerii*, based on suspected optimal habitat and potential vulnerability to low flow. The 25 sites had one or more of the following characteristics: 1) stable, gently sloping banks primarily vegetated with newly established black willow, 2) dense and species-rich mussel assemblages, 3) firm substratum consisting of silty sand, and/or 4) signs of recent mussel mortality from low water in 2006 and 2007. Most areas were along a moderately depositional reach immediately downriver of a point bar.

Methods

2003 Studies. Mussels were collected using a 6-person dive crew equipped with surface supplied air and communication equipment on 18-20 November 2003. During the survey period, gage height and discharge at Blountstown (NM 78) was 3.63 ft, 9,420 cfs (18 Nov 03), 4.17 ft, 10,300 cfs (19 Nov 03), and 4.94 ft 11,500 cfs (20 Nov 03). All underwater collecting was done tactilely since visibility was poor. Divers were equipped with a pneumofathometer to record water depth and were tethered to the boat with a 100-m line. Transects were laid perpendicular to shore, running from shallow (2 ft) to deep water (9 ft). Two divers collected mussels for 15 min at each 1-ft depth increment along the transect. This qualitative sampling protocol provided data and information on Catch per Unit Effort (CPUE), and percent species abundance at each 1-ft depth increment.

2007 Studies. In 2007 mussels were collected by hand while wading and no divers were used; therefore, the maximum water depth searched was 3 ft. Quantitative and qualitative methods were used at 10 of the 25 areas, and only qualitative methods were used at the remaining areas. Quantitative sampling included placing six evenly spaced transects perpendicular to shore. Mussels were collected with a 0.25 m^2 quadrat at three sites along each transect moving from near- to farshore (1, 2, and 3 ft depths). All sediment, shells, and live bivalves were excavated to a depth of 15-25 cm (6 to 10 inches) from the quadrat and sieved through a screen (minimum mesh size equaled 6.4 mm, 0.25 inch). Live mussels and the Asian clam *Corbicula fluminea* were identified and counted. A total of 18 quantitative samples were obtained at each site; therefore, 180 quantitative samples were taken. In addition to the quantitative samples, a 10 to 20-min timed search was conducted between two transect lines in the center of the area.

At each of the remaining 15 areas, only a single 10-15 min timed search was conducted and no quantitative samples were taken. After processing, all mussels were returned to the river unharmed. See Miller and Payne (2005), and Miller and Payne (2007) for more information on methods and sample areas.

Essentially the same sampling strategy was used in 2003 and 2007. Since mussels were collected at 1-ft depth increments, results (density or relative abundance) could be expressed in terms of water depth or elevation. At each collecting site, water elevation data were converted to discharge by Mobile District personnel based on recent ratings data provided by the U.S. Geological Survey. This procedure enabled us to estimate the number of mussels that could be exposed to the atmosphere if water level and discharge declined. Mussels exposed to the atmosphere during low flow will not necessarily be killed; an unknown number will likely move into deeper water. In addition, some exposed mussels could survive for days or weeks if they are shaded and partially buried in moist sediment. However, mussels exposed or located in extremely shallow water would likely experience more stress due to low water quality and high temperature and would be more susceptible to predation and mortality.

Results

Comparison of 2003 and 2007 studies. During the 2003 survey, total discharge (ranging between 9,420 cfs and 11,500 cfs) was considerably higher than in 2007 when discharge was approximately 5,000 cfs. Therefore, during the latter survey, all of the sites sampled in 2003 were exposed to the atmosphere. In addition, sites surveyed in 2007 would have been at lower elevations than those sampled during 2003.

In the 2003 survey, the maximum recorded density (2.0 individuals / m^2) was at NM 41.5, at a depth of 4 ft, which corresponded to a discharge of 6,400 cfs (Figure 1, taken from data discussed in Miller and Payne 2005). In the 2007 survey, the maximum recorded density (22.7 individuals / m^2) was at NM 43.9, at a depth of 2 ft, which corresponded to a discharge of 3,150 cfs (Figure 2). Not only were density values greater in 2007, but mussels were collected at much lower elevations than they were in 2003. It must be emphasized that these samples were obtained in the same river reach but not the same locations or type of habitat (disposal areas in 2003 versus more optimal habitat conditions in 2007). The site located at NM 43.9 could always have supported a higher mussel density than the site at NM 41.5.

Depth distribution analysis based on qualitative sampling in 2007. Qualitative data collected from the 15 sites where partial studies were conducted were converted to density and plotted for three depth elevations: 1, 2, and 3 ft, which corresponded to discharge values of 4,150, 3,200, and 2,250 cfs, respectively. (This was done using a regression equation developed from data collected using both quantitative and qualitative methods; see Miller and Payne 2007 for more details). Figures 3 and 4 present density and percent abundance values summarized for all sites. Cumulative densities include all mussels collected along the transect moving from shallow to deep water. Percentages include the proportion of mussels at each depth increment calculated from density values. The cumulative percent value represents accumulated density moving from shallow to deep water. For example, at a discharge of 2,250 cfs all mussels (a cumulative density greater than 4 individuals/m^2, 100% of the assemblage) could be exposed to the atmosphere. (For these and all remaining figures, cumulative density and percent values for 0.5 ft depth increments are displayed; our field collections were only obtained at 1.0-ft increments). As stated above, some of these mussels could move to deeper water and some could be taken by predators. Abundance values for a representative low and a high-density site (NM 42.2 and 47.4) are depicted in Figures 5 and 6.

Predicted density versus discharge for all sites sampled using qualitative methods, with the exception of DM01 and DM12 (where no *A. neislerii* were found) are displayed in Appendix A.

Depth distribution analysis based on quantitative sampling in 2007. Quantitative data collected along transects in 2007 were summarized for all sites (Figure 7). Figure 8 includes percent abundance and cumulative percent abundance data based on all quantitative samples. Mean density for all sites studied in 2007 was greater than the highest density site sampled in 2003 (compare Figure 7 with Figure 1). Density, cumulative density, percent abundance, and cumulative percentage were plotted for a representative low-density site (Figures 9 and 10), and a representative high-density site (Figures 11 and 12).

Mean density versus discharge for all sites sampled using quantitative methods are displayed in Appendix B.

Summary and Conclusions

Concern over negative effects of discharge less than 5,000 cfs in the Apalachicola River due to low rainfall triggered the need to more fully investigate the depth-distribution of *A. neislerii,* a federally protected species. Results of qualitative (timed collections using search by feel methods) and quantitative sampling (total excavation of 0.25 m^2 quadrats) conducted in 2003 and 2007 were used to examine possible effects of extremely low discharge. Depth distribution data were collected in 2003 and 2007 by collecting mussels at known water depths along transects perpendicular to shore running from shallow to deep water. Field-collected water elevation data were converted to discharge values by Mobile District personnel. The objective of both surveys was to develop an understanding of the impacts of extreme low water on *A. neislerii* assemblages.

Results of both surveys illustrate that *A. neislerii* (and most other mussel species in this river) inhabit a fairly narrow band along the shore in reaches with suitable water velocity and substrate. In 2003 the maximum *A. neislerii* abundance was found at a depth of 4 ft; no live mussels were collected in water deeper than 9 ft. In 2007 all collecting was done without divers; therefore, it is not possible to know abundance and distribution of mussels in water deeper than 3 ft. Regardless, comparing results of both surveys suggest that mussels moved into deeper water in response to reduced discharge. In the latter survey, mussels were abundant at elevations corresponding to 3,150 cfs; depths that did not support live mussels in 2003 (compare Figures 1 and 2).

Amblema neislerii density was higher in 2007 than in 2003 in the same river reach. The maximum density in 2003 was 2.0 individuals/m^2, recorded at NM 41.5, at a depth of 4 ft. In 2007 the maximum recorded density was 22.7 individuals / m^2, recorded at NM 43.9 at a depth of 2 ft. Since none of the sites studied in 2003 were re-surveyed in 2007, a direct comparison between study years cannot be done. However, it is possible that the higher densities recorded in 2007 could have been the result of a large number of mussels moving to lower elevations because of reduced water. It is also possible that the areas surveyed in 2007 were better habitat than those studied in 2003 and therefore supported more mussels.

Results of the 2007 survey indicated that a 1-ft loss in water level, below a discharge of 5,150 cfs, to an equivalent flow of approximately 4,150, could expose less than 25% of the *A. neislerii*. A 2-ft decline in water level, corresponding to a discharge of 3,200 cfs, could expose approximately 75% of the mussels (see Figure 8, 10, and 12). Obviously a 2-ft decline in water level could result in more than twice the mortality if water only dropped by 1 ft. As stated above, all exposed mussels would not necessarily be killed by a 1-ft reduction in water level; some could move into deeper water and survive. Regardless, it is uncertain if habitat conditions in the deeper water areas would provide suitable habitat under higher flow conditions due to potential differing geomorphic conditions.

Results from the 2003 and 2007 studies indicated that mussels are able to avoid atmospheric exposure and occupy habitat with suitable depth, velocity, and substratum. As long as water levels remain low, mussels are likely to do well at these previously unoccupied sites. Regardless, if in the future water discharge and velocity increase, these mussels could be vulnerable to sheer stress far in excess of what they can tolerate. These mussels could be eroded out of the substratum and displaced downriver. It is possible that some individuals could be carried to suitable areas and survive, although others could be deposited in the main channel and be killed.

Because divers were not used in the 2007 survey, it is not possible to determine if additional mussels are present at depths greater than 3 ft. Based on 2003 data, the highest mussel densities could be in water 4 ft deep. Therefore, our 2007 survey could have underestimated the number of mussels present.

Using results of 2003 and 2007, the total number of mussels in a river reach exposed to the atmosphere for incremental lower flow conditions could be estimated. However, it would not be advisable to make these estimates without more rigorous sampling (greater replication) over greater areas using divers.

Results of this analysis suggest the need for additional mussel studies in the Apalachicola River. Primarily, there is a need to collect deeper than 3 ft under flow conditions similar to those during the 2007 survey. In addition, there is a need for at least three other studies: 1) Describe the location and aerial extent of mussel habitats that are particularly vulnerable to low flow; 2) Estimate the total abundance of federally-protected mussels by depth distribution using a more rigorous sampling design (more subsites at each area and more replication within each subsite), and 3) Relate mussel abundance and distribution to geomorphic processes at specific sites. Data and information obtained from these studies would assist in assessing the impacts of extreme low flow on *A. neislerii* in the Apalachicola River.

Literature Cited

Miller, A. C. and B. S. Payne. 2005. Depth Distribution of the Fat Threeridge Mussel, *Amblema neislerii*, during Low Flow Stages on the Apalachicola River, Florida US Army Engineer Research and Development Center, Vicksburg, MS.

Miller, A. C. and B. S. Payne. 2007. Factors Determining Abundance and Distribution of the Endangered Fat Threeridge mussel, *Amblema neislerii*, in the Apalachicola River, Florida. Report submitted to the US Army Engineer District Mobile, 2007

Table 1. Location of samples sites searched for *A. neislerii*, November 2003. Surveys were conducted immediately downriver of 5 Disposal Areas (DA), along the shore, near the mouth of Douglas Slough, and at 2 sites near the entry of the Chipola Cutoff off the Apalachicola River. This table originally appeared in Miller and Payne (2005).

WP	Date	Time	Longitude	Latitude	Notes	NM
145	18-Nov-03	2:54:00 PM	85.11685	30.02453	Near mouth of Douglas Slough	30.0
150	19-Nov-03	9:24:00 AM	85.11959	30.1978	DA 65A	48.4
152	19-Nov-03	10:28:00 AM	85.11996	30.1978	DA 65A	48.4
153	19-Nov-03	11:32:00 AM	85.11645	30.20457	DA 66A	49.0
154	19-Nov-03	12:58:00 PM	85.09632	30.22057	DA 70	53.4*
155	19-Nov-03	2:15:00 PM	85.13486	30.18173	DA 63	46.8
156	19-Nov-03	3:42:00 PM	85.147	30.12915	Near entry into the Chipola Cutoff	41.5
157	19-Nov-03	5:09:00 PM	85.14982	30.13413	500 m inside the Chipola Cutoff	41.5
158	20-Nov-03	7:55:00 AM	85.02044	30.39815	DA 107A	73.3
159	20-Nov-03	8:59:00 AM	85.02091	30.39801	DA 107A	73.3
160	20-Nov-03	9:45:00 AM	85.02015	30.39808	DA 107A	73.3

*Note - Although mussels were found at NM 53.4, no *A. neislerii* were collected at this location

Table 2. Summary information on study areas in the Apalachicola River, 7-11 June 2007. See also Figure 1 and Figures B1 – B4, and Table B1, Appendix B. (Reach length measurements were provided by USFWS). This table originally appeared in Miller and Payne (2007).

NM	Bank	Location	Bank	Waypoints	Survey Type	Length, m
40.3	RDB	DSDM01	RDB	143-144	Partial	No data
40.4	RDB	DM01	RDB	141-142	Partial	64.2
40.5	LDB	DM'09	LDB	134-139	Detailed	40.6
40.6	LDB	DM10	LDB	128-133	Detailed	78.4
41.0	LDB	DM11	LDB	186-187	Partial	85.2
41.3	LDB	DM12	LDB	168-169	Partial	192.3
41.7	LDB	DM13	LDB	166-167	Partial	68.5
42.1	RDB	DM'03	RDB	164-165	Partial	41.9
42.2	LDB	DM'02	LDB	162-163	Partial	238.5
42.7	LDB	DM'04	LDB	152-153	Partial	40.9
42.8	RDB	DM'05	RDB	145-151	Detailed	127.0
43.0	LDB	DM'06	LDB	156-161	Detailed	90.9
43.1	LDB	DM'07	LDB	154-155	Partial	67.4
43.4	RDB	DM'08	RDB	180-185	Detailed	144.2
43.9	RDB	DM15	RDB	201-206	Detailed	212.6
44.3	LDB	DM14	LDB	188-193	Detailed	77.0
44.5	RDB	DM16	RDB	170-175	Detailed	87.8
45.5	LDB	DM17	LDB	176-177	Partial	169.2
46.0	RDB	DM18	RDB	222-227	Detailed	66.5
46.4	LDB	DM19	LDB	196-197	Partial	159.5
46.9	RDB	DM20	RDB	207-208	Partial	No data
47.4	RDB	DM21	RDB	209-210	Partial	277.5
47.5	LDB	DM22	LDB	214-215	Partial	217.3
48.2	LDB	DM23	LDB	216-221	Detailed	107.9
48.7	RDB	DM24	RDB	228-229	Partial	101.0
49.6	RDB	DM26	RDB	230-231	Partial	309.9

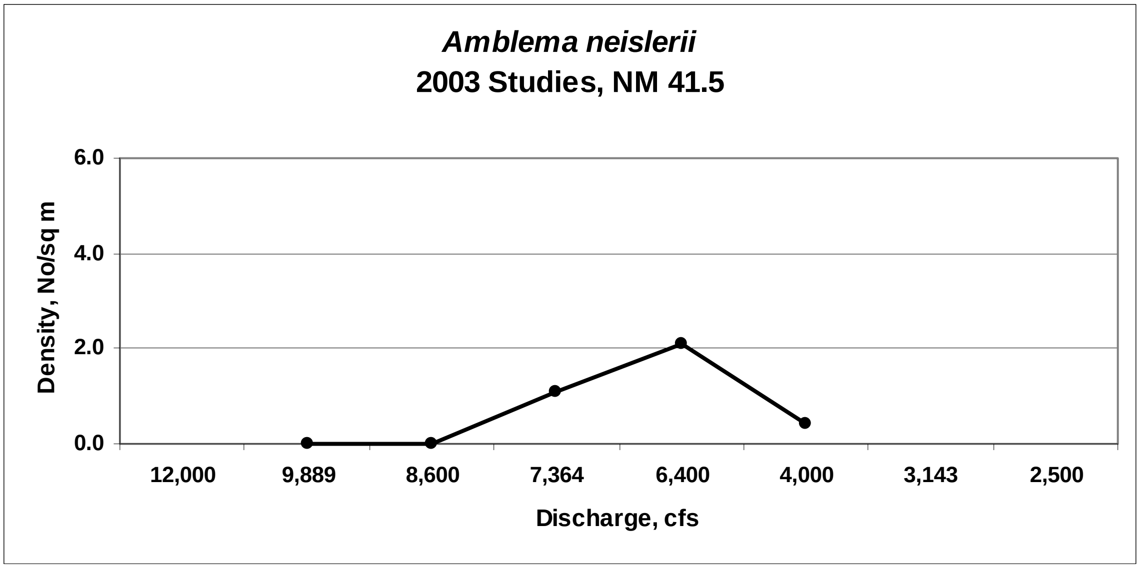


Figure 1. Depth distribution of *Amblema neislerii*, NM 41.5, Apalachicola River, Florida, 2003. Data were obtained by divers using qualitative methods, and then converted to density values. 12,000 cfs corresponds to the approximate edge of the water, 9,889 cfs is at approximately 1 ft deep, etc. This figure is based on data collected in 2003 and discussed in Miller and Payne 2005.

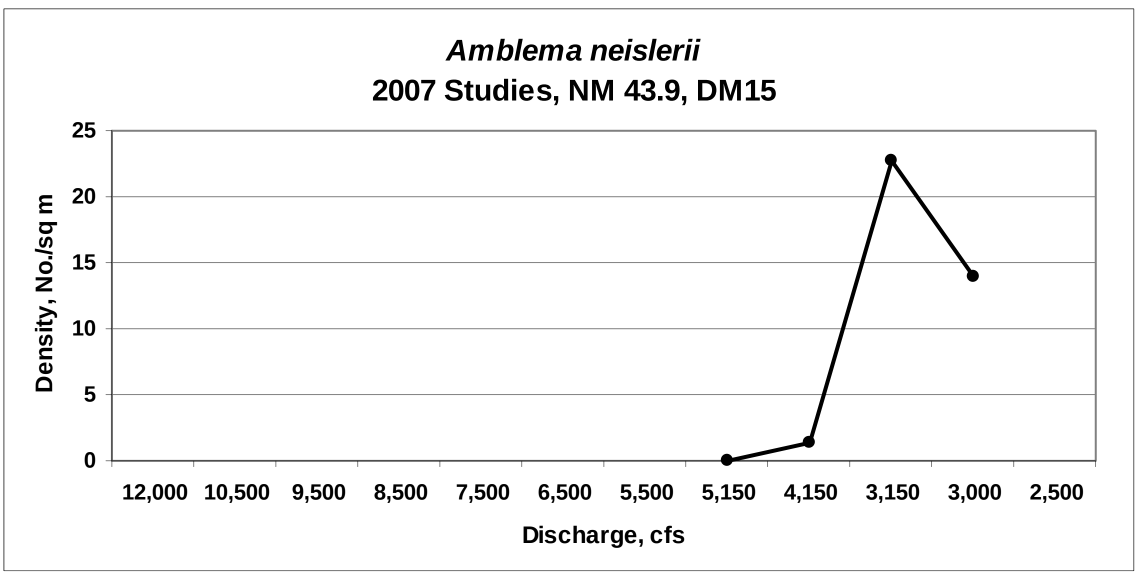


Figure 2. Depth distribution of *Amblema neislerii*, NM 43.9, DM15, Apalachicola River, Florida, 2007. Mussels were using quantitative methods by waders. Data are shown for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively.

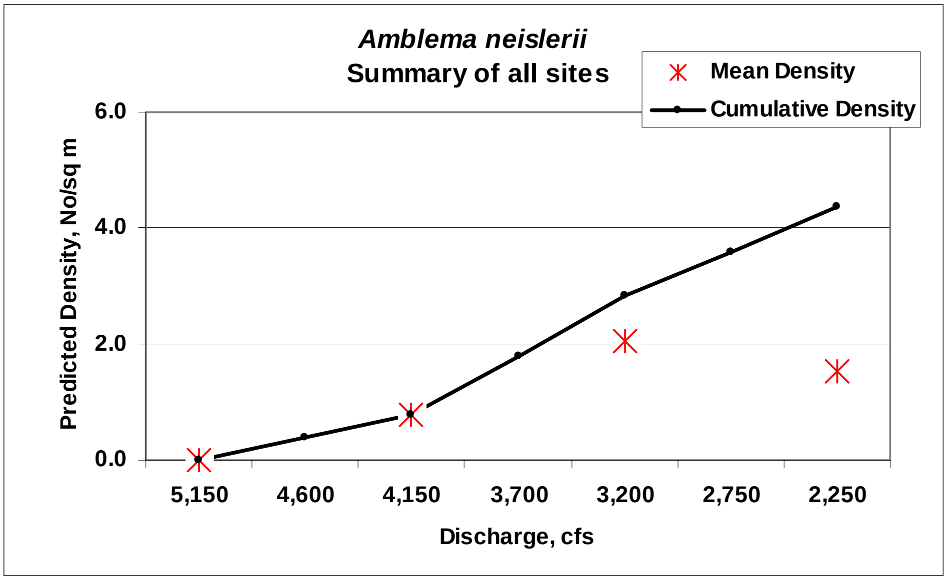


Figure 3. Overall mean density and cumulative density of *Amblema neislerii* for sites along the Apalachicola River, Florida, 2007, sampled using qualitative methods. Data are shown for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively. Density values were estimated from the relationship between CPUE and quantitative (0.25 m^2) sampling at nearby sites.

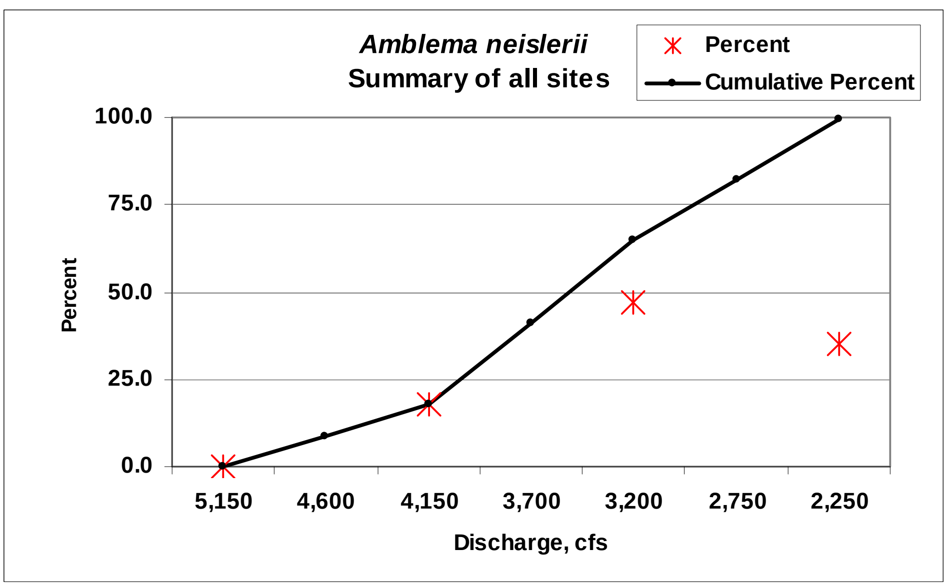


Figure 4. Overall mean percent and cumulative percent (based on qualitative samples) of *Amblema neislerii* at sites along the Apalachicola River, Florida, 2007, sampled using qualitative methods. Results are portrayed for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively.

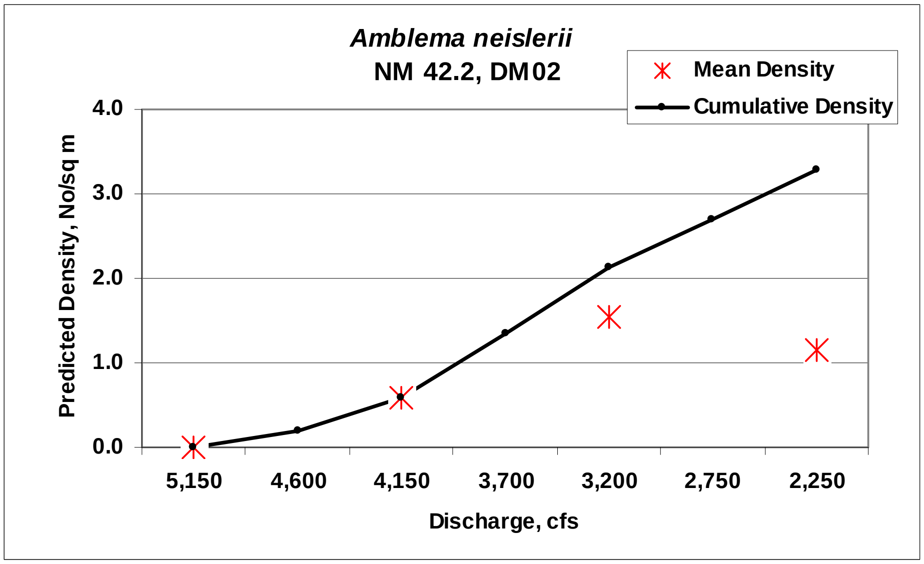


Figure 5. Overall mean density and cumulative density of *Amblema neislerii* for a low density site at NM 42.2, DM02, Apalachicola River, Florida, 2007, sampled using qualitative methods. Data are shown for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively. Density values were estimated from the relationship between CPUE and quantitative (0.25 m^2) sampling at nearby sites.

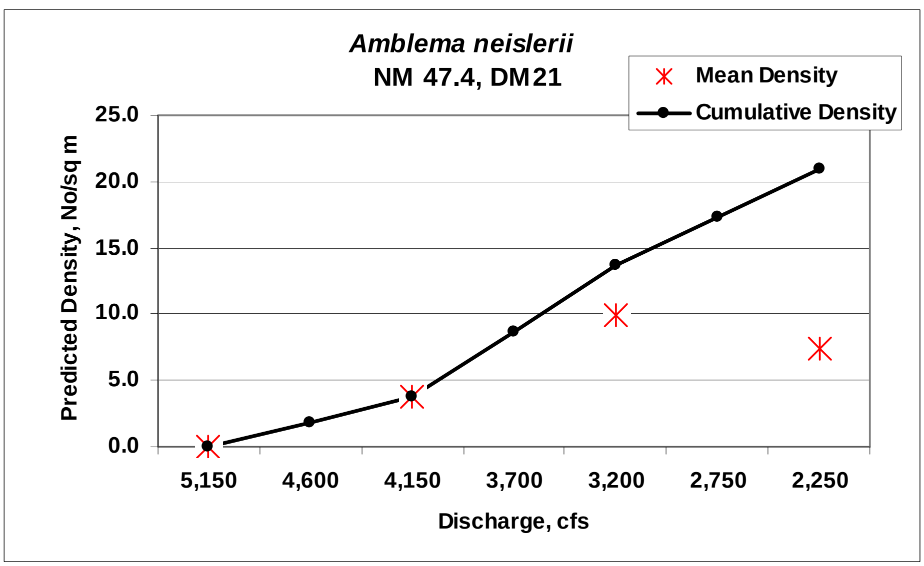


Figure 6. Overall mean percent and cumulative percent (based on qualitative samples) of *Amblema neislerii* for a high density site at NM 47.4, DM21 along the Apalachicola River, Florida, 2007, sampled using qualitative methods. Results are portrayed for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively.

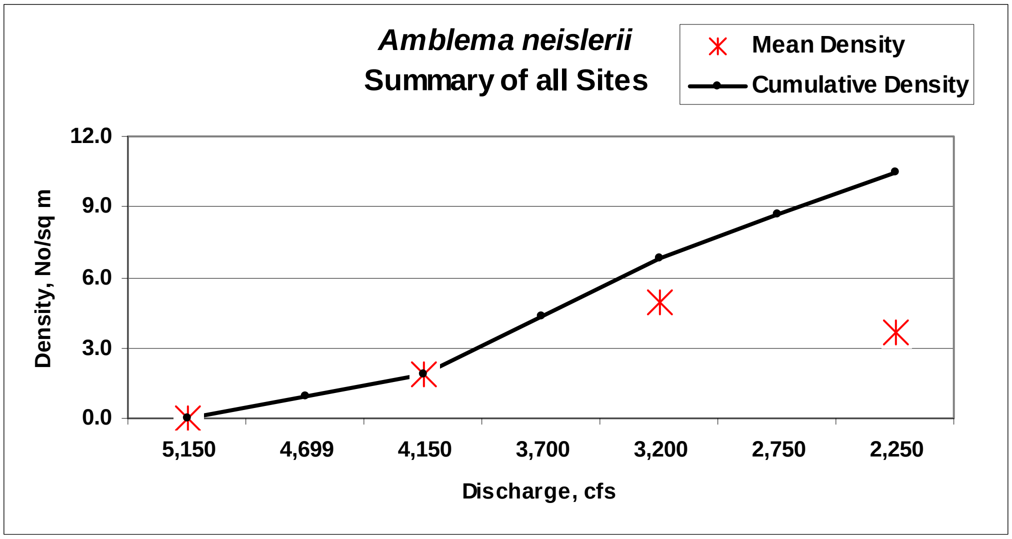


Figure 7. Overall mean density and cumulative density of *Amblema neislerii* for 10 sites along the Apalachicola River, Florida, 2007, sampled using quantitative methods. Data are shown for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively. Density values were estimated from the relationship between CPUE and quantitative (0.25 m^2) sampling at nearby sites.

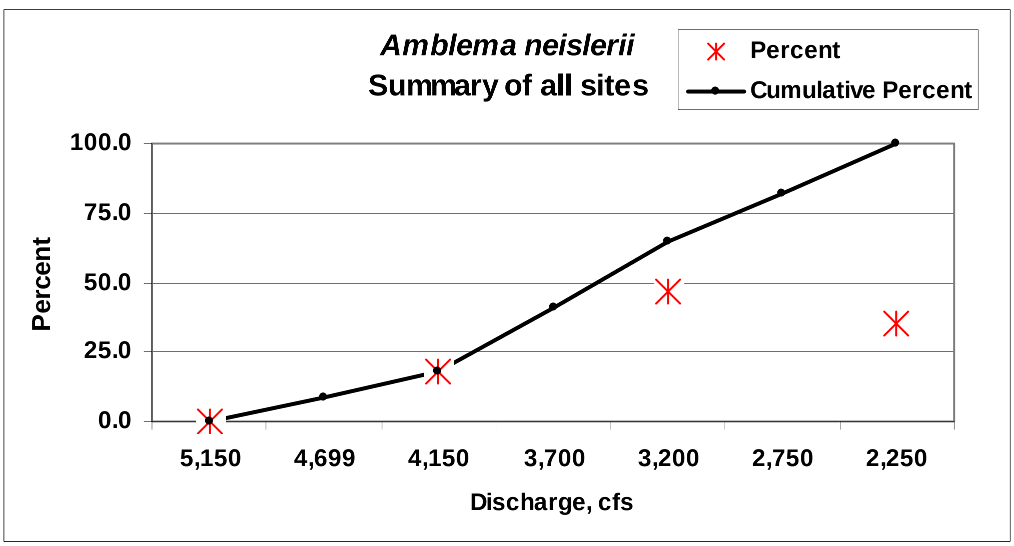


Figure 8. Overall mean percent and cumulative percent (based on quantitative samples) of *Amblema neislerii* at 10 sites along the Apalachicola River, Florida, 2007. Results are portrayed for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively.

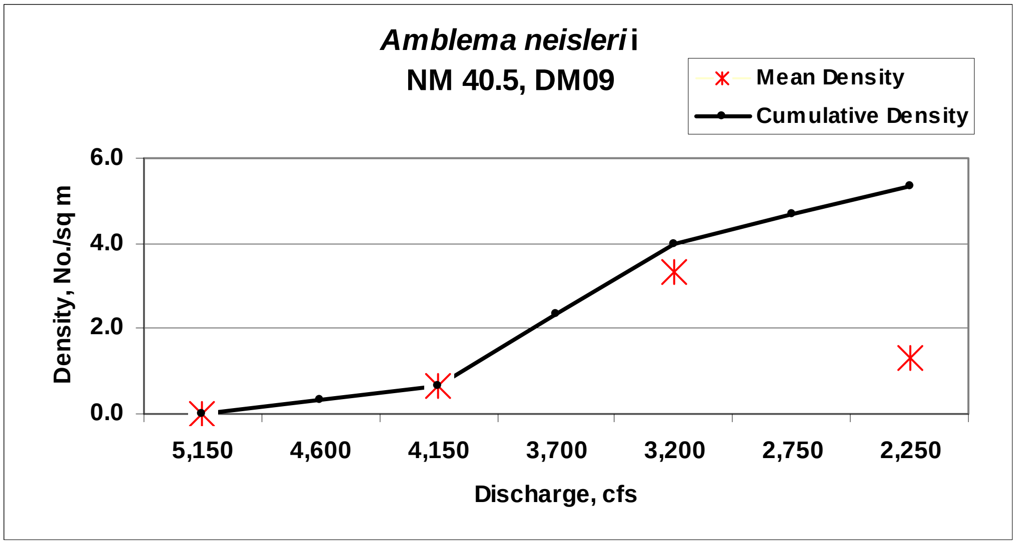


Figure 9. Overall mean density and cumulative density of *Amblema neislerii* for a low density site at NM 40.5, DM09, Apalachicola River, Florida, 2007, sampled using quantitative methods. Data are shown for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively. .

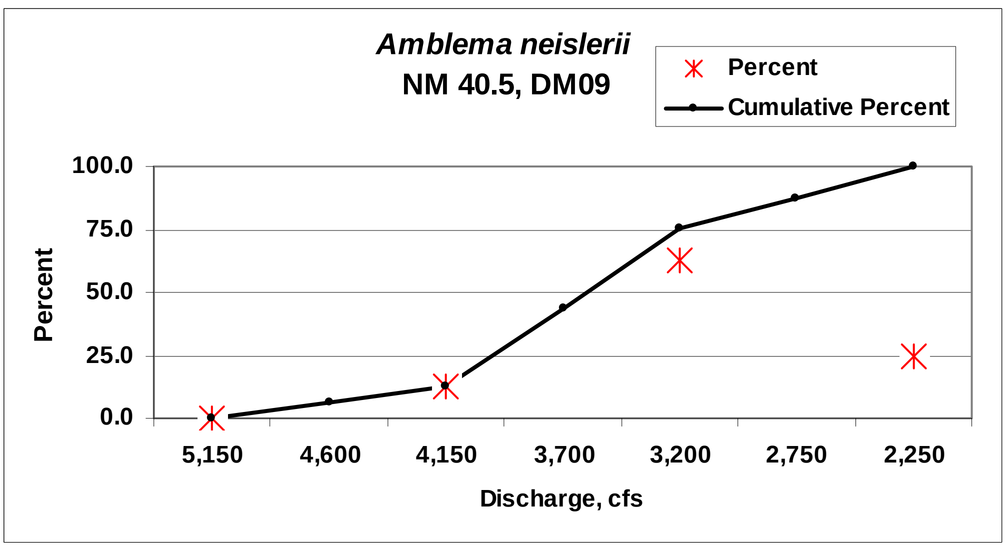


Figure 10. Overall mean percent and cumulative percent of *Amblema neislerii* for a low density site at NM 40.5, DM09, Apalachicola River, Florida, 2007, sampled using quantitative methods. Results are portrayed for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively

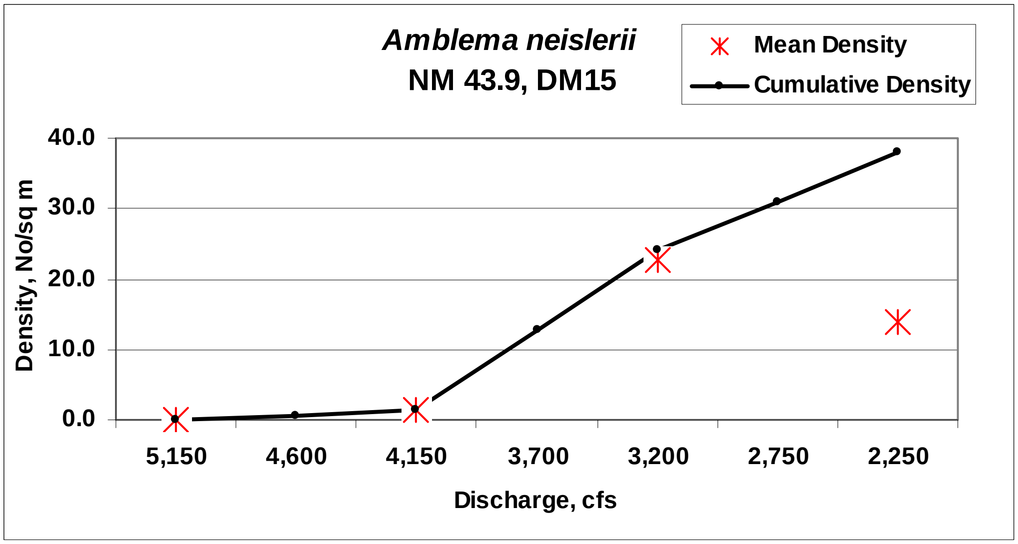


Figure 11. Overall mean density and cumulative density of *Amblema neislerii* for a high density site at NM 43.9, DM15, Apalachicola River, Florida, 2007, sampled using quantitative methods. Data are shown for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively. .

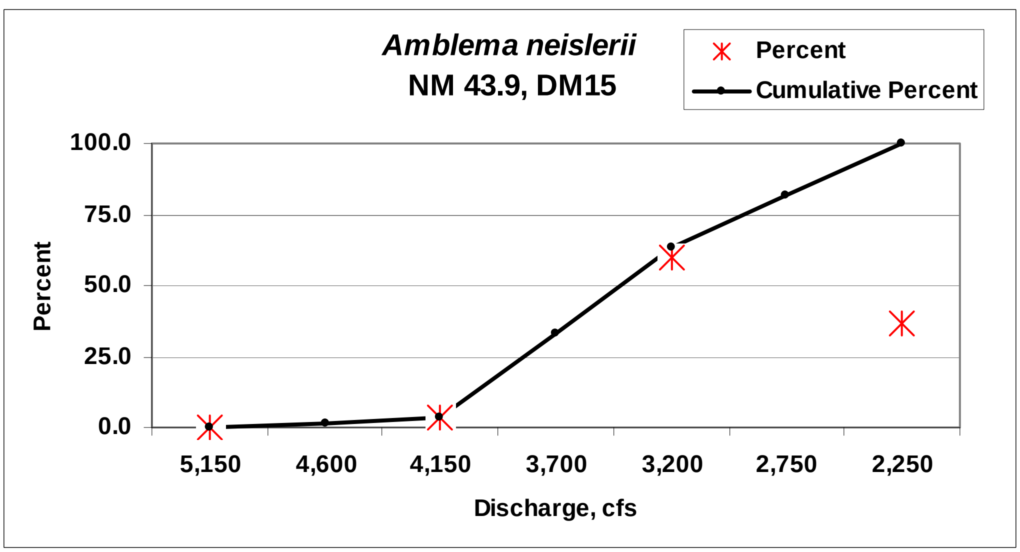


Figure 12. Overall mean percent and cumulative percent of *Amblema neislerii* for a high density site at NM 43.9, DM15, Apalachicola River, Florida, 2007, sampled using quantitative methods. Results are portrayed for the edge of the water (5,150 cfs) and at three depths (1, 2, and 3 ft), which corresponds to 4,150, 3,200, and 2,250 cfs, respectively.

Appendix A

Effects of low discharge on density of *A. neislerii*, Apalachicola River, Florida, 2007, based on qualitative sampling

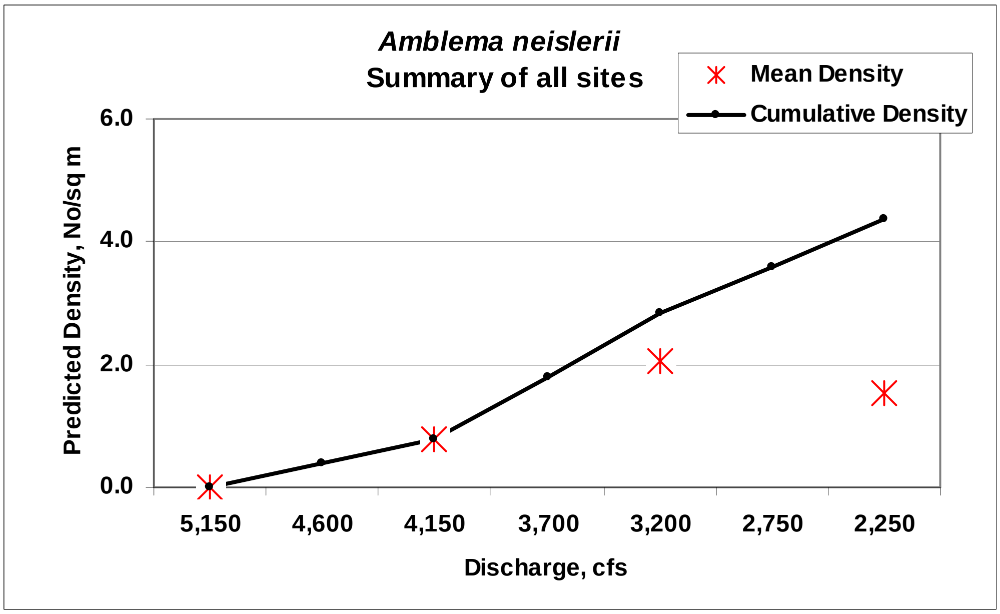


Figure A1

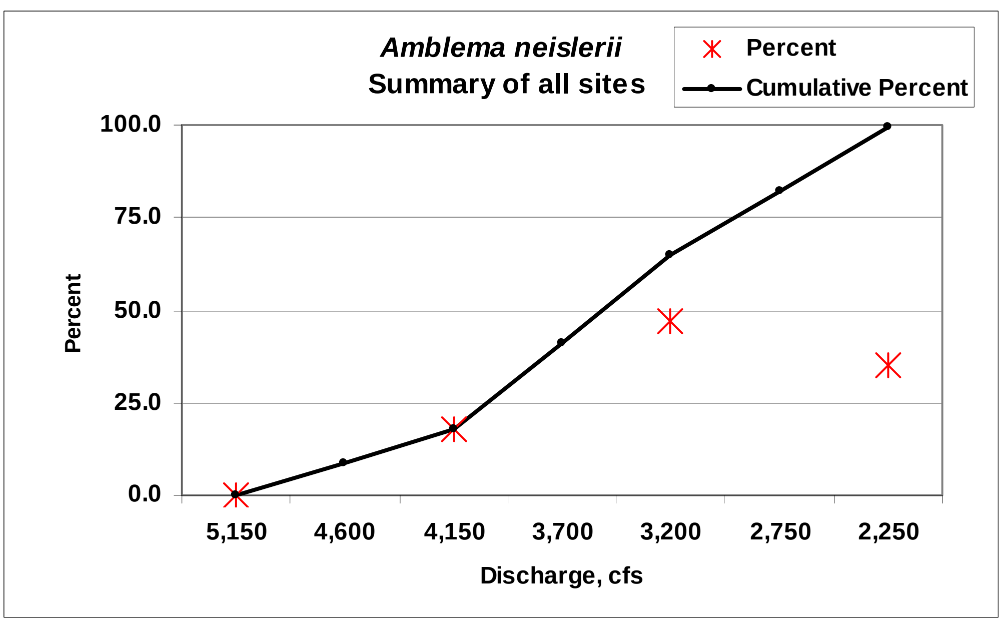


Figure A2

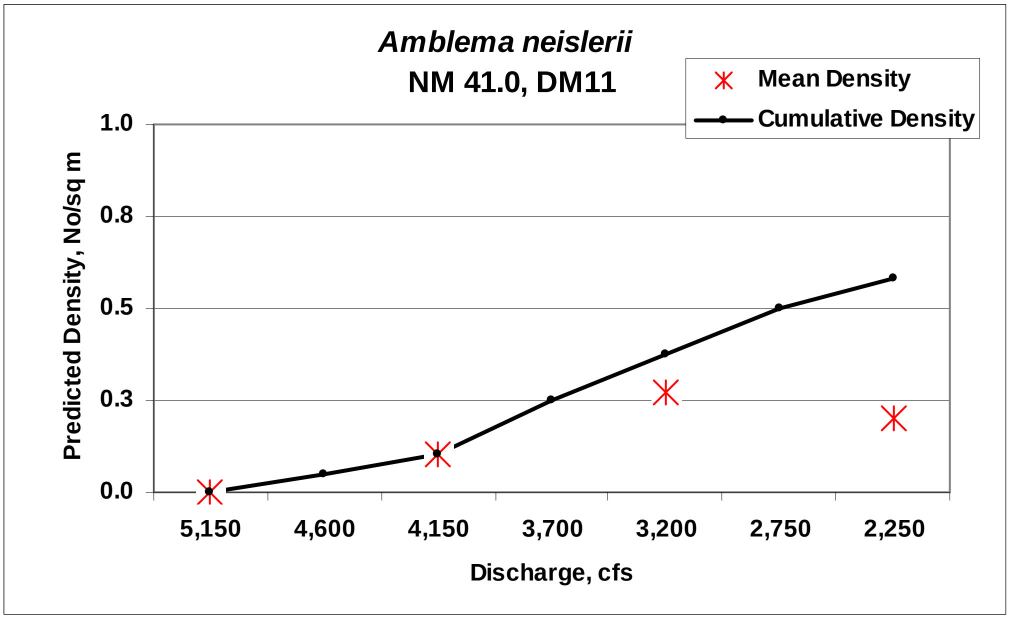


Figure A3

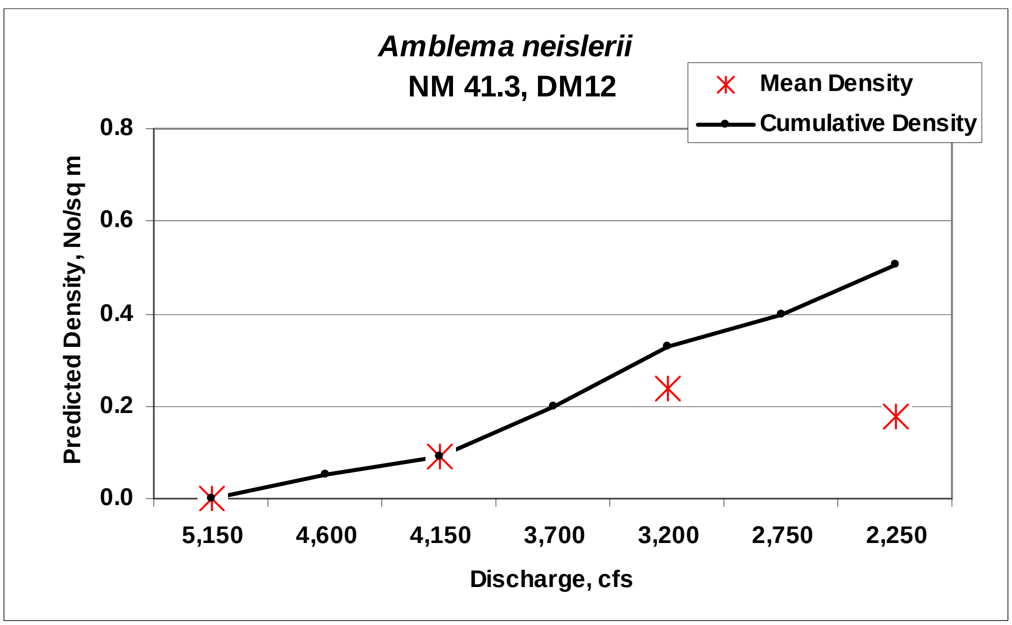


Figure A4

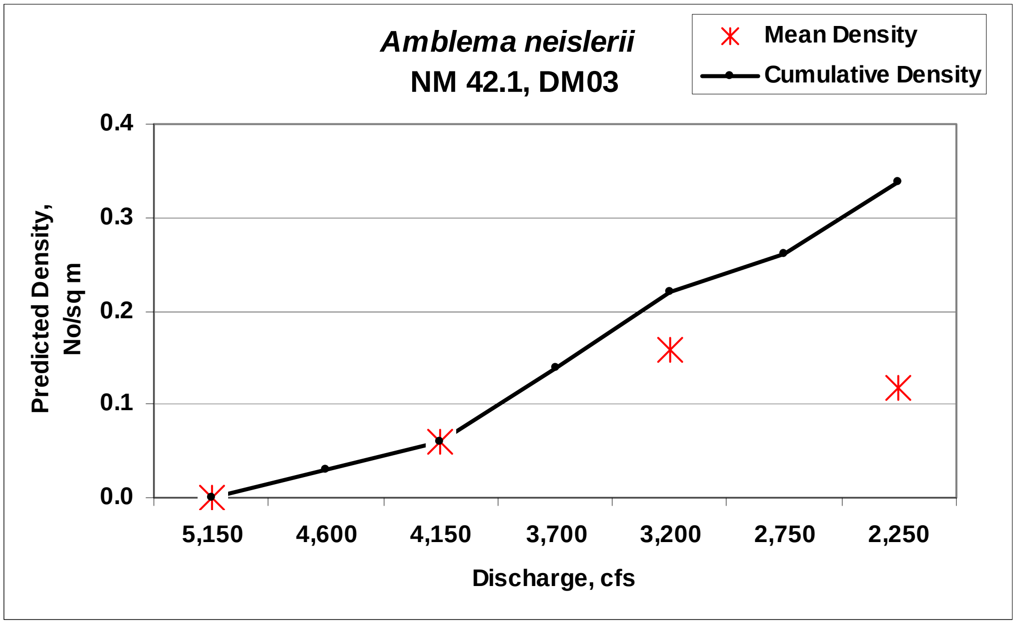


Figure A5

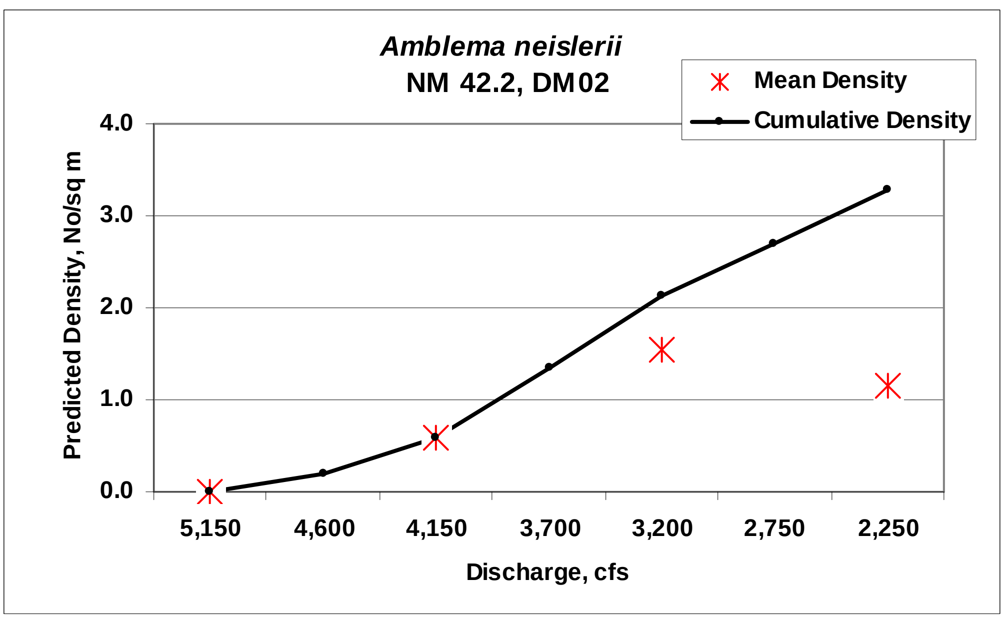


Figure A6

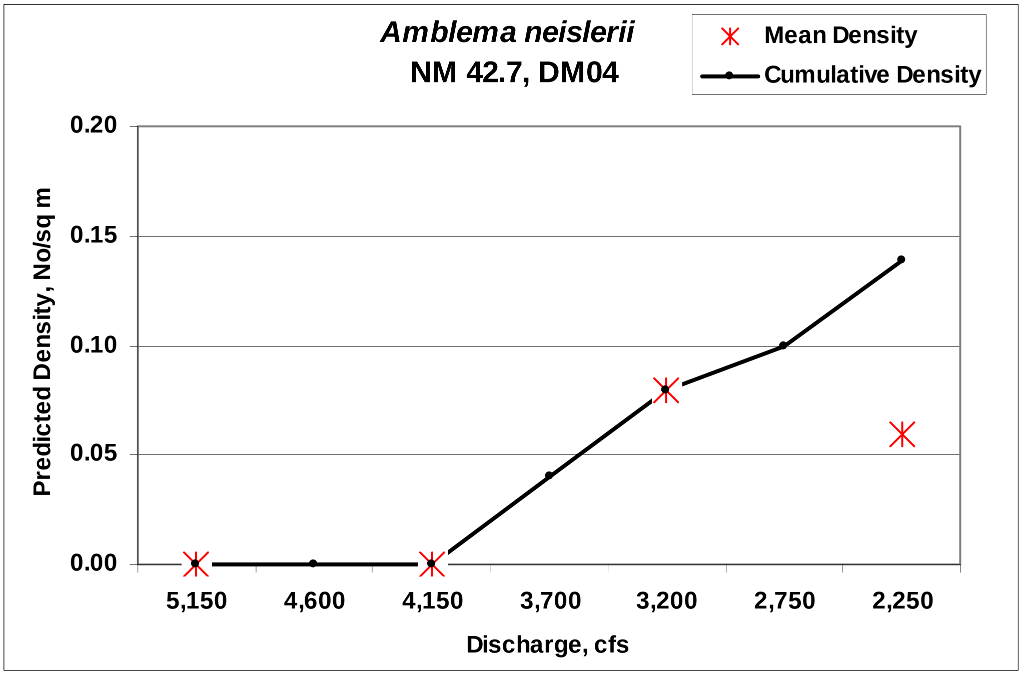
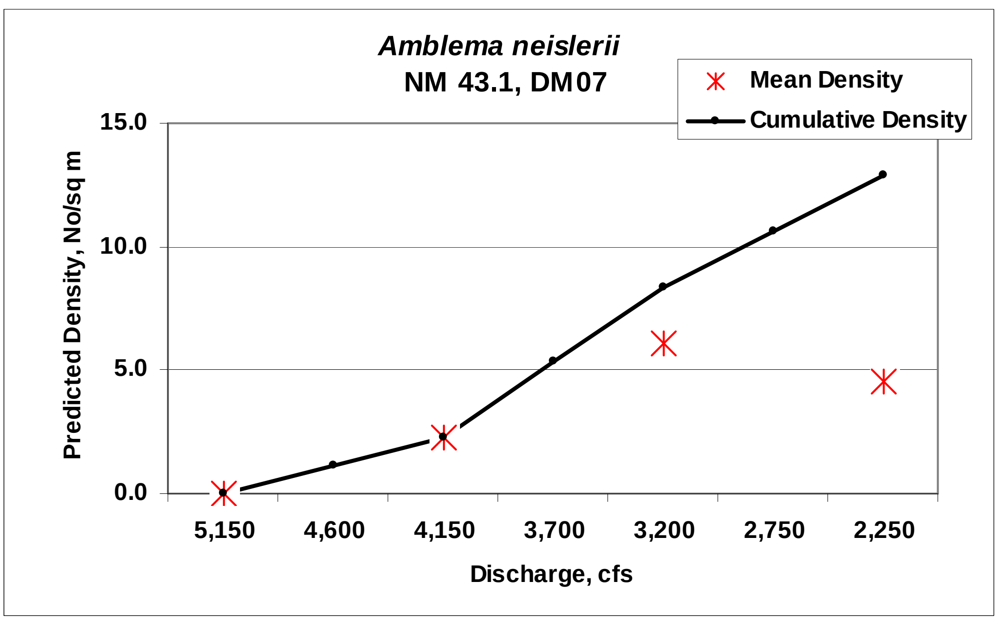


Figure A7



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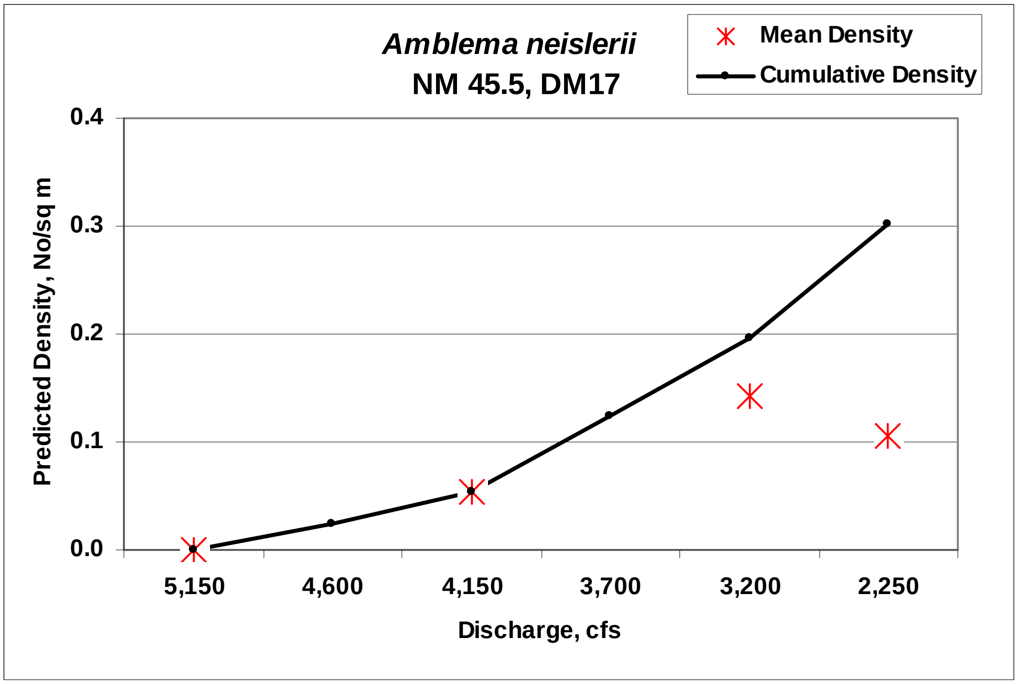

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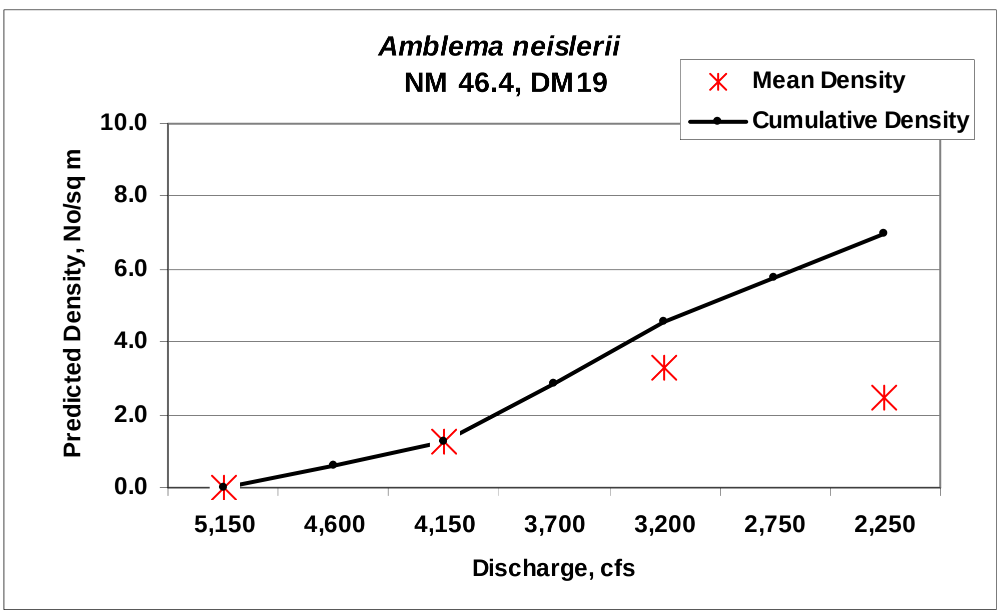

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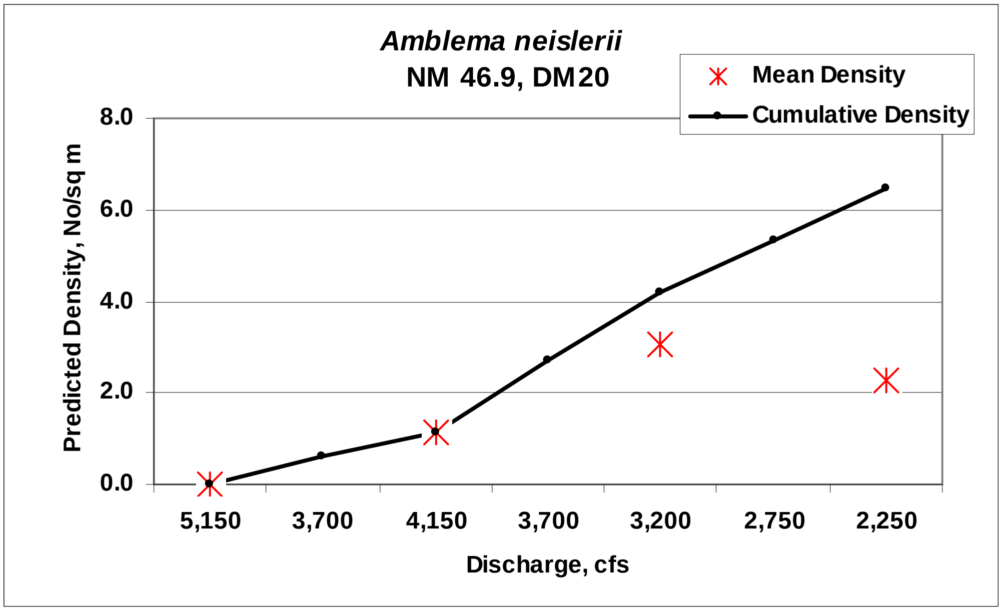

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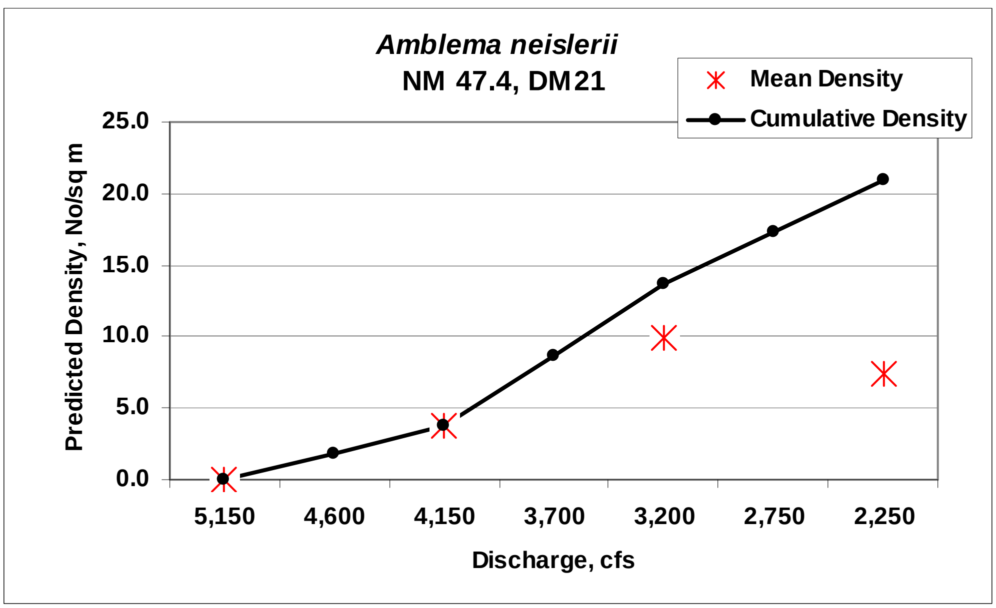

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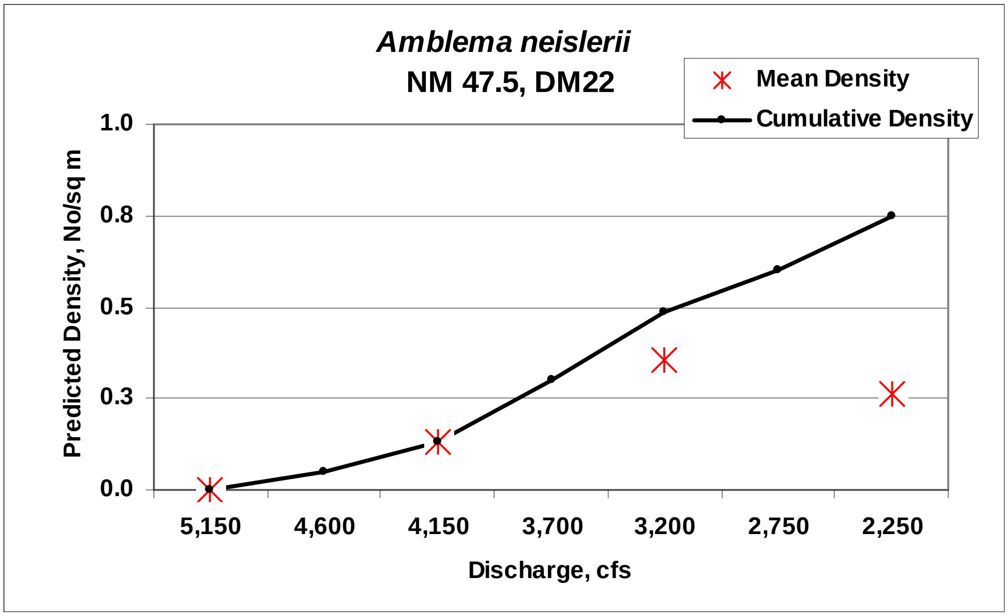
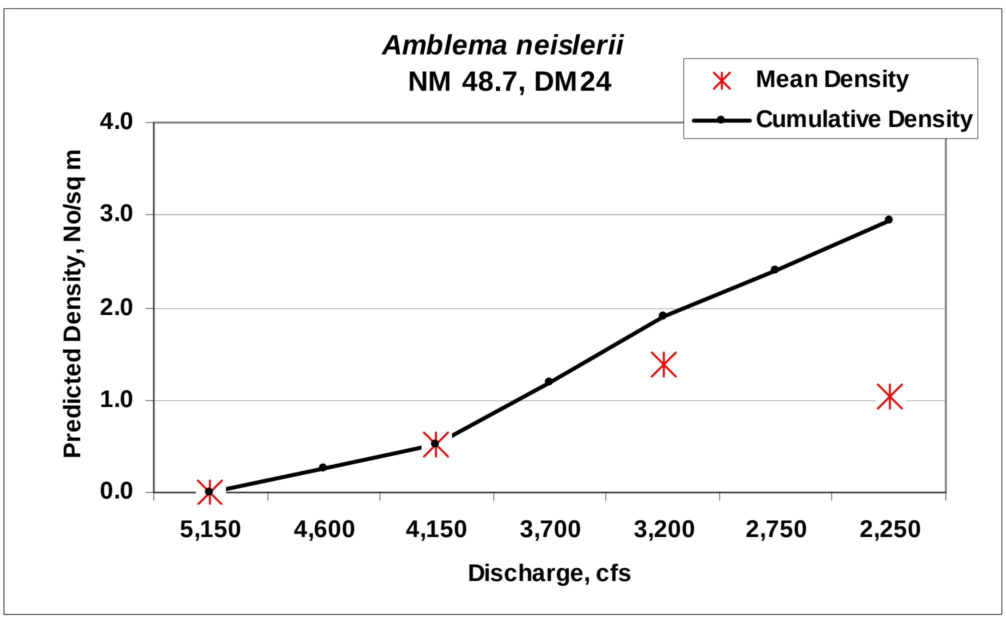


Figure A13



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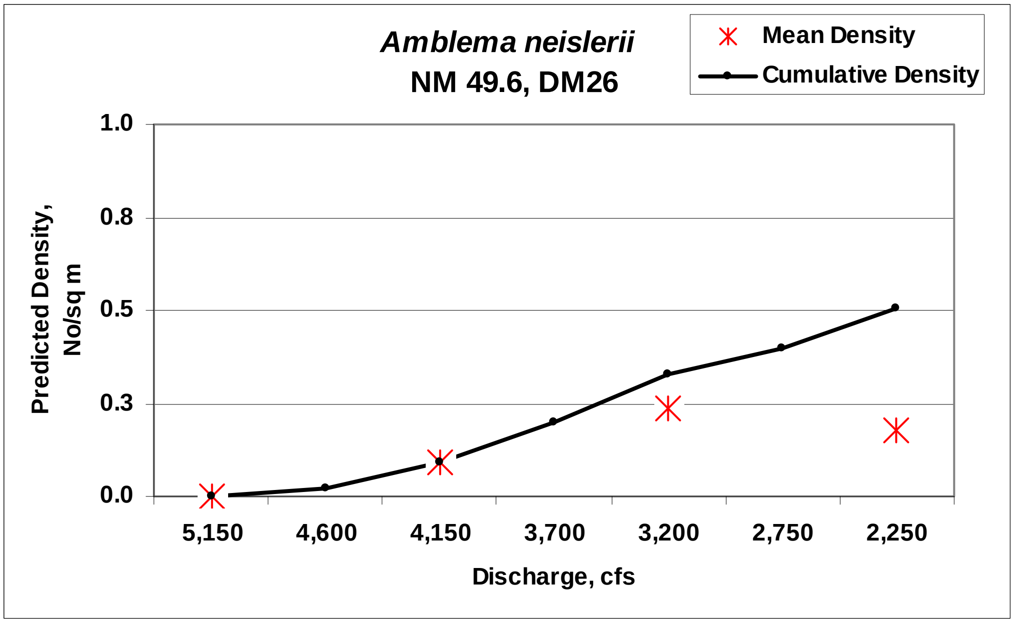


Amblema neislerii
NM 49.6, DM26
Mean Density
Cumulative Density
1.0
0.8
0.5
0.3
0.0
Predicted Density, No/sq m
5,150
4,600
4,150
3,700
3,200
2,750
2,250
Discharge, cfs

Figure A15

Appendix B

Effects of low discharge on density and percent abundance of *A. neislerii*, Apalachicola River, Florida, 2007, based on quantitative sampling

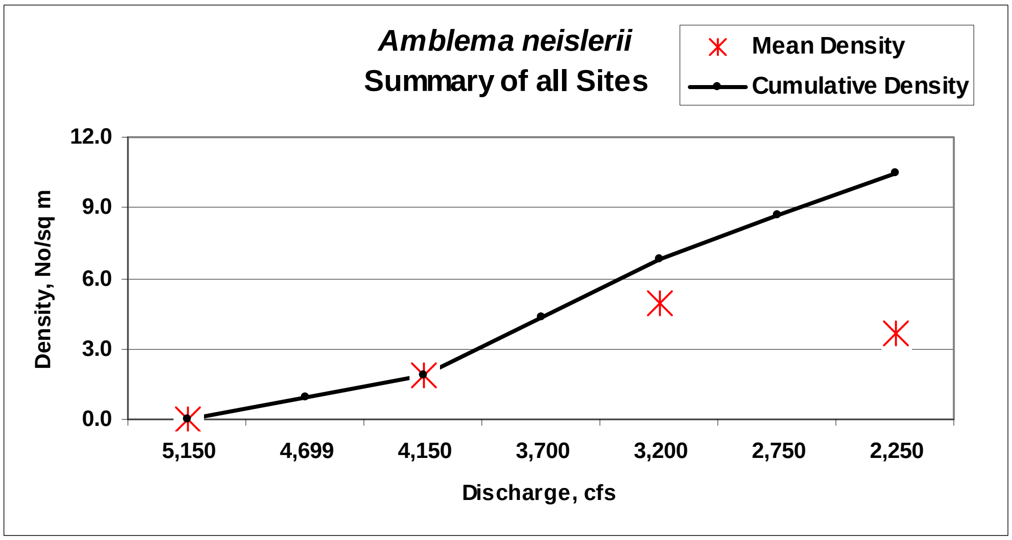


Figure B1

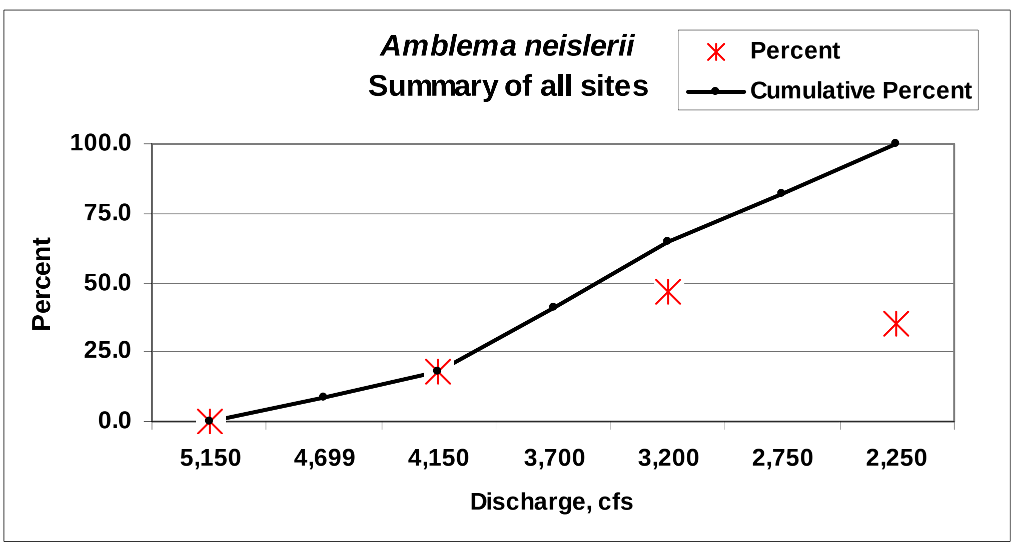


Figure B2

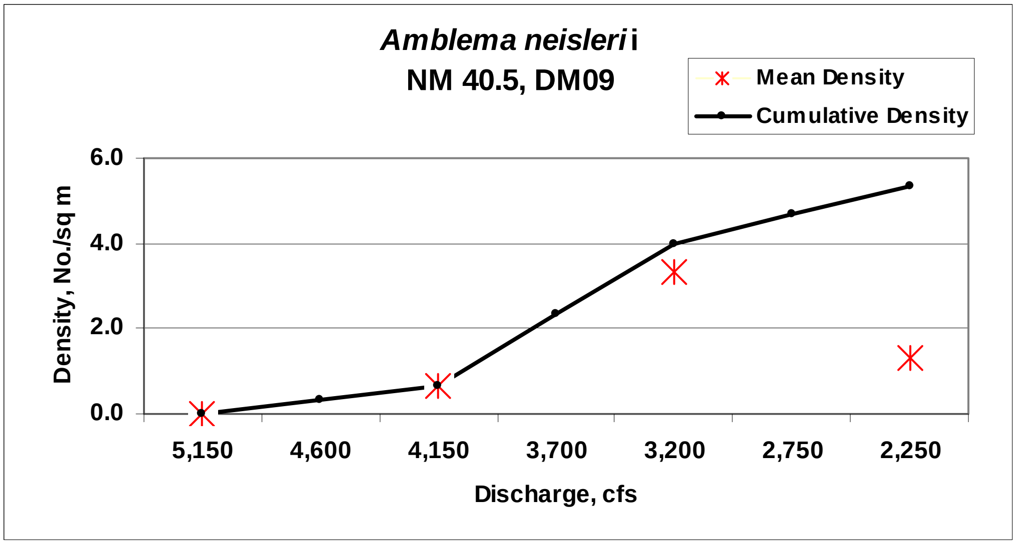


Figure B3

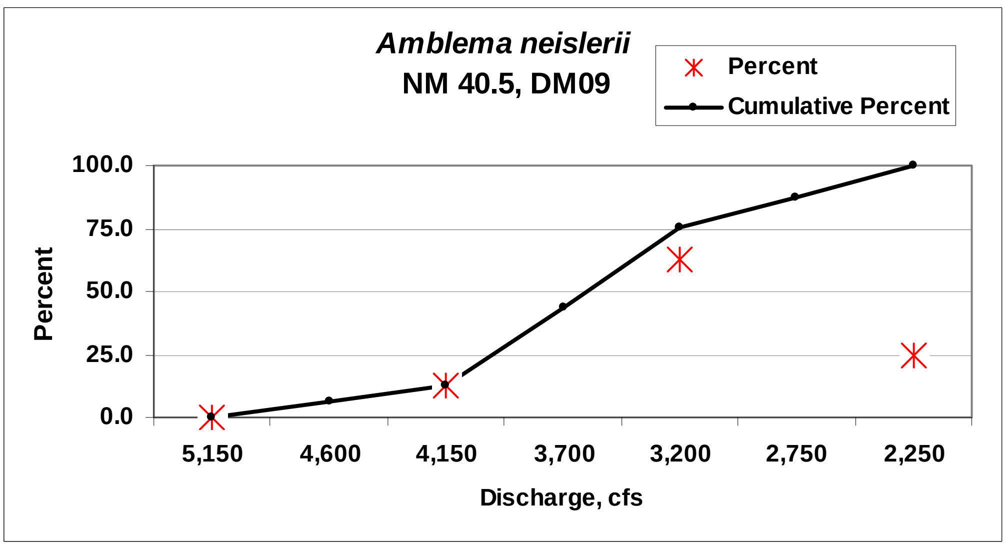


Figure B4

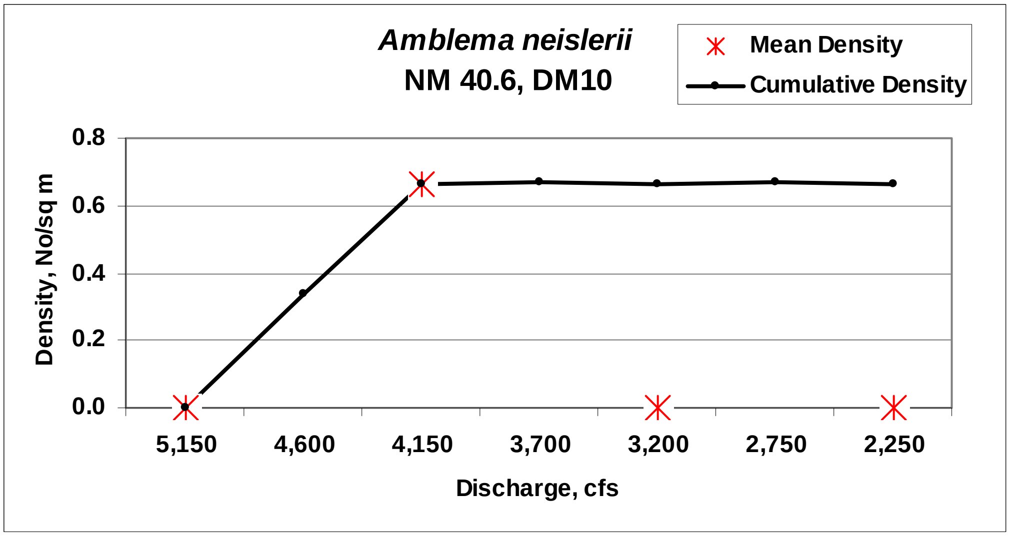


Figure B5

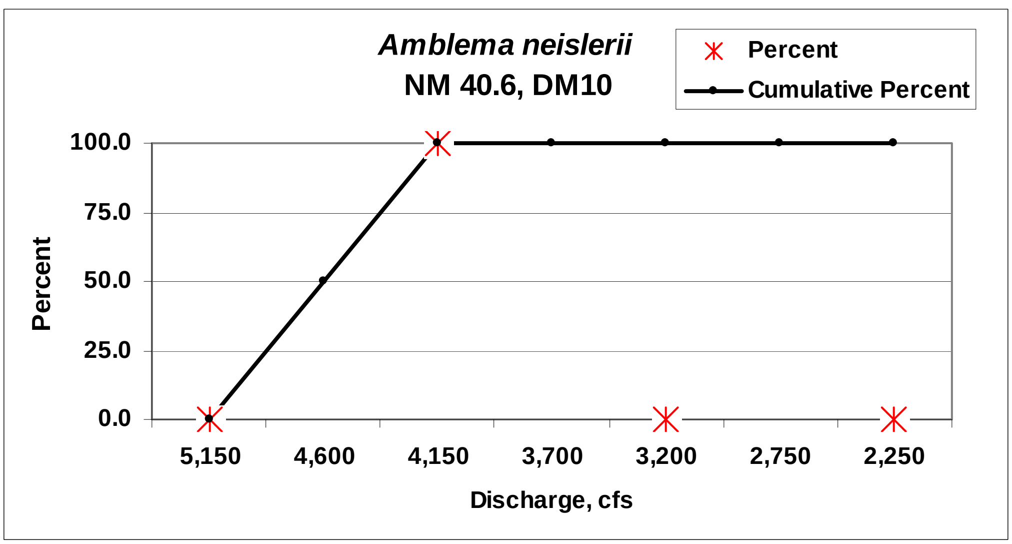
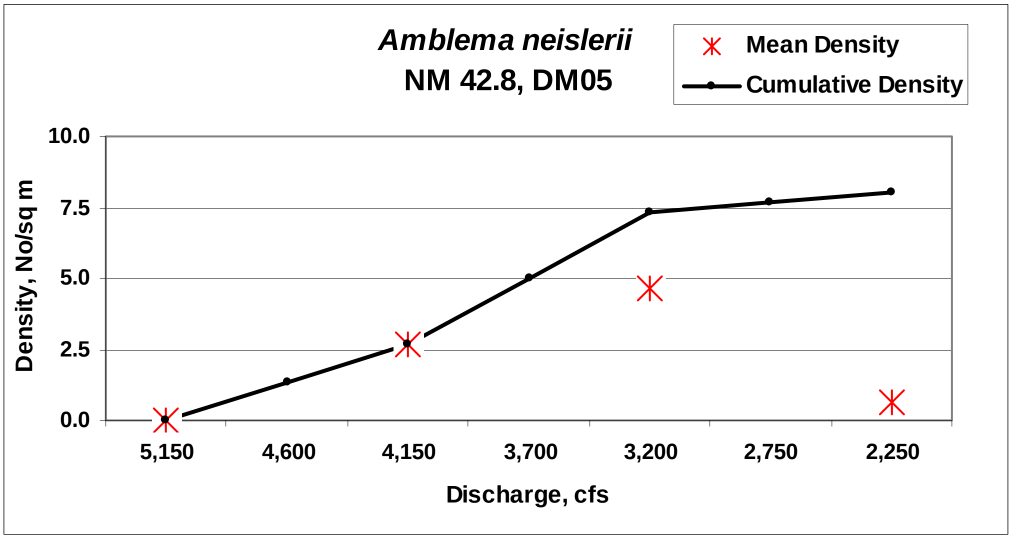


Figure B6



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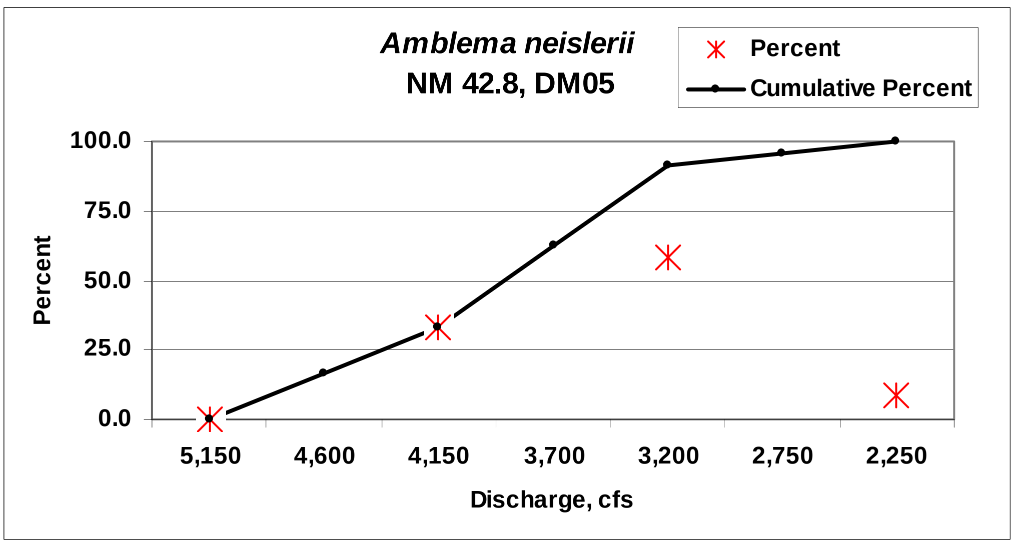

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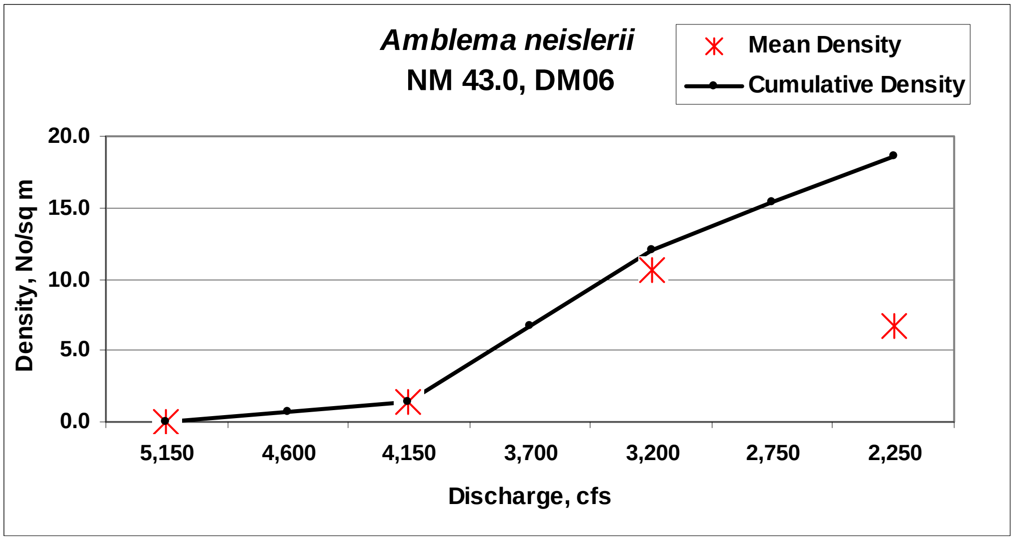
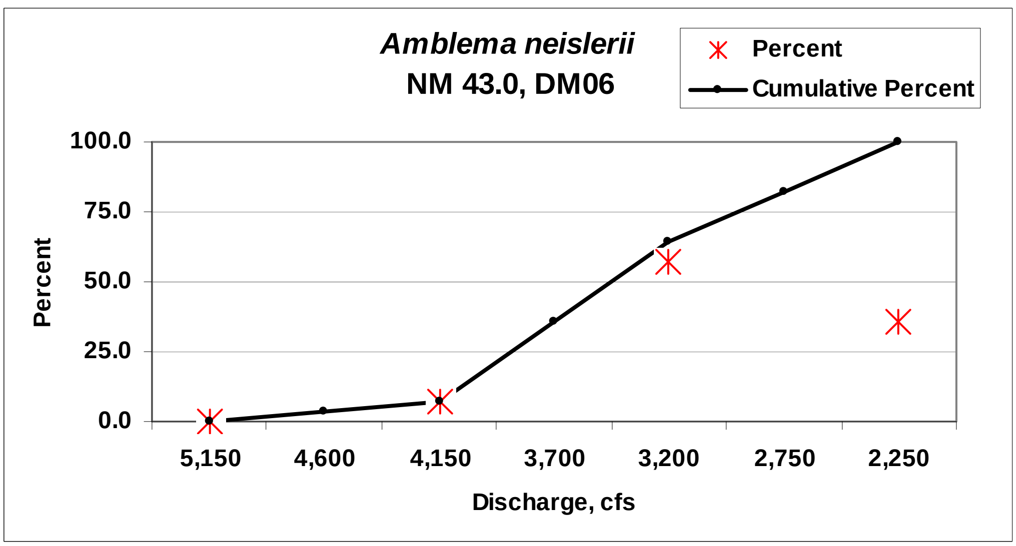


Figure B9



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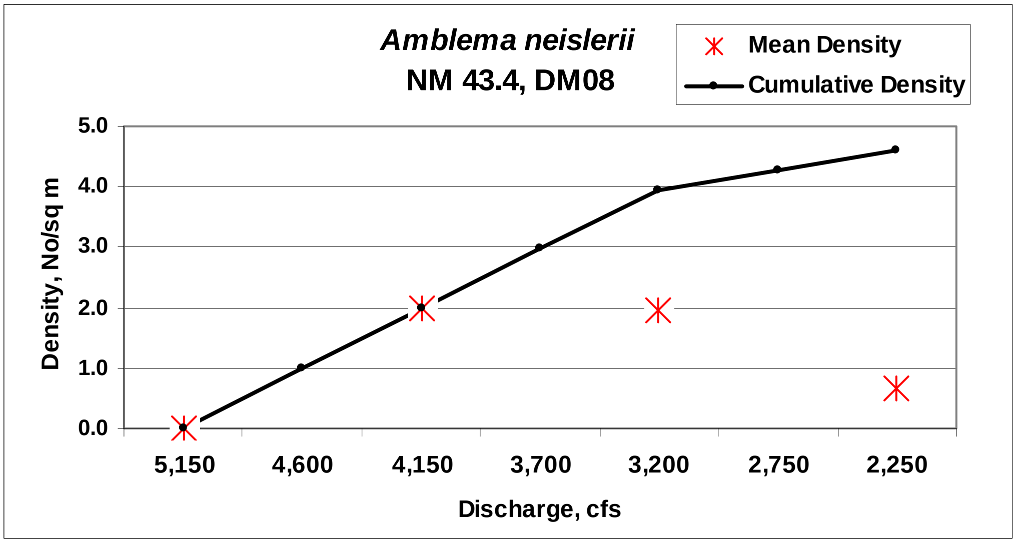
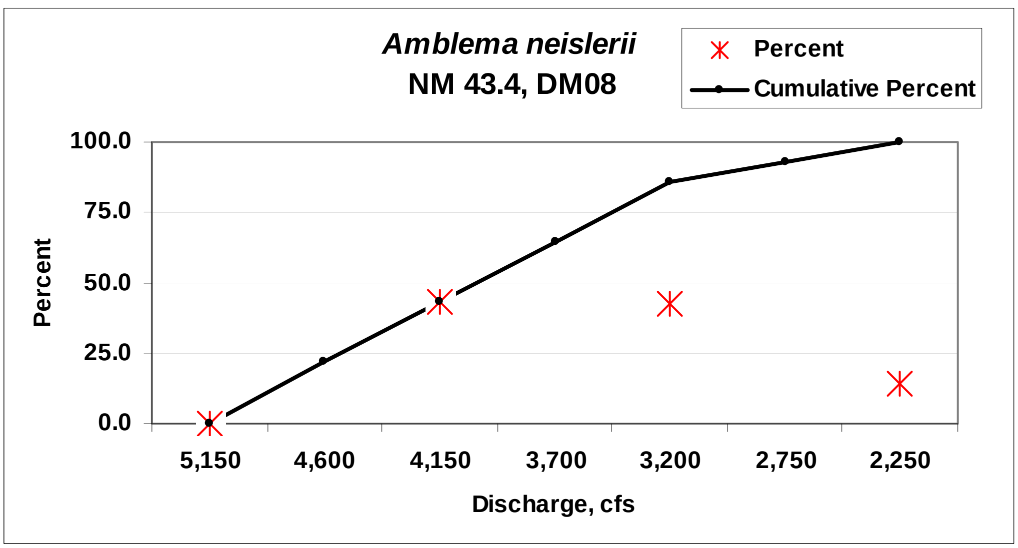


Figure B11



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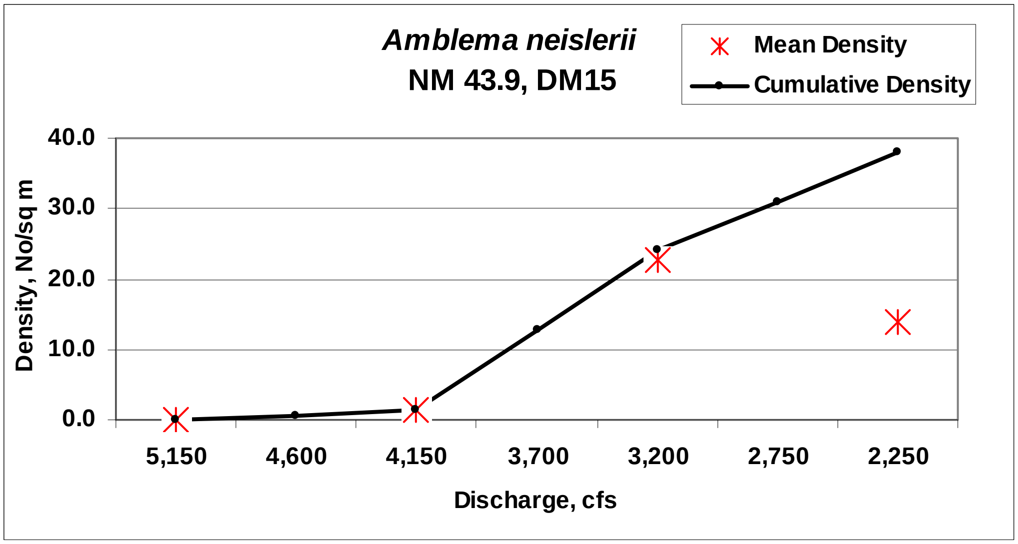

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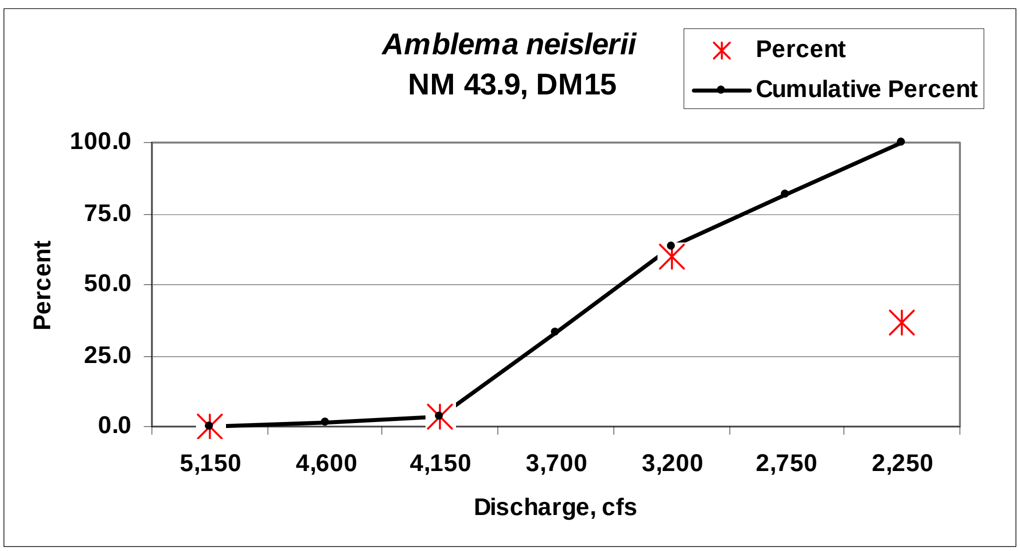

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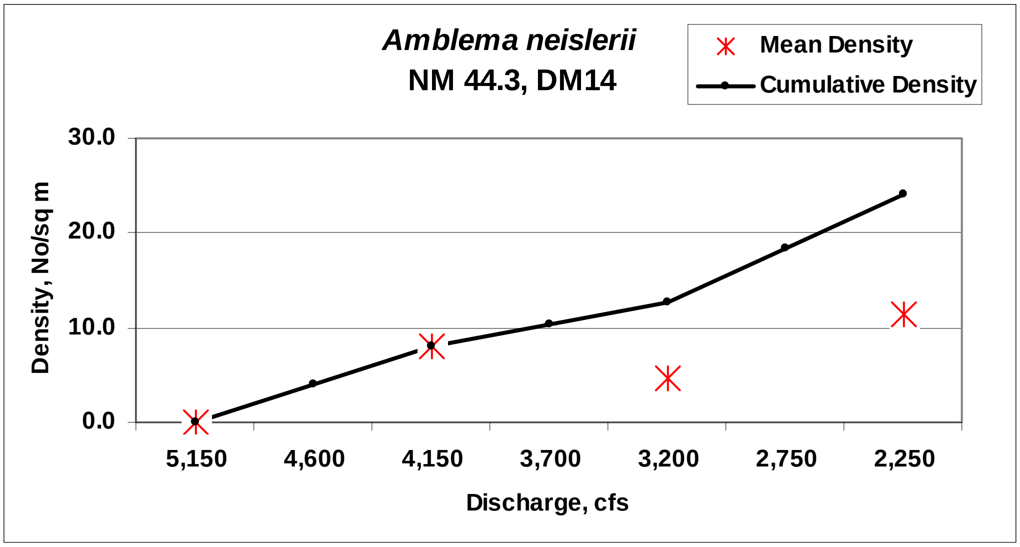

Figure B15

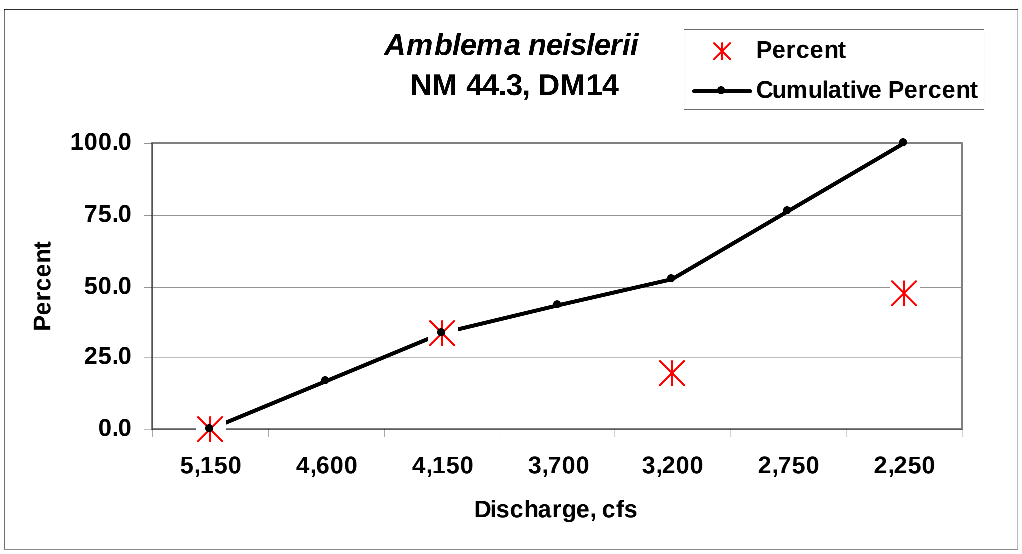

Figure B16

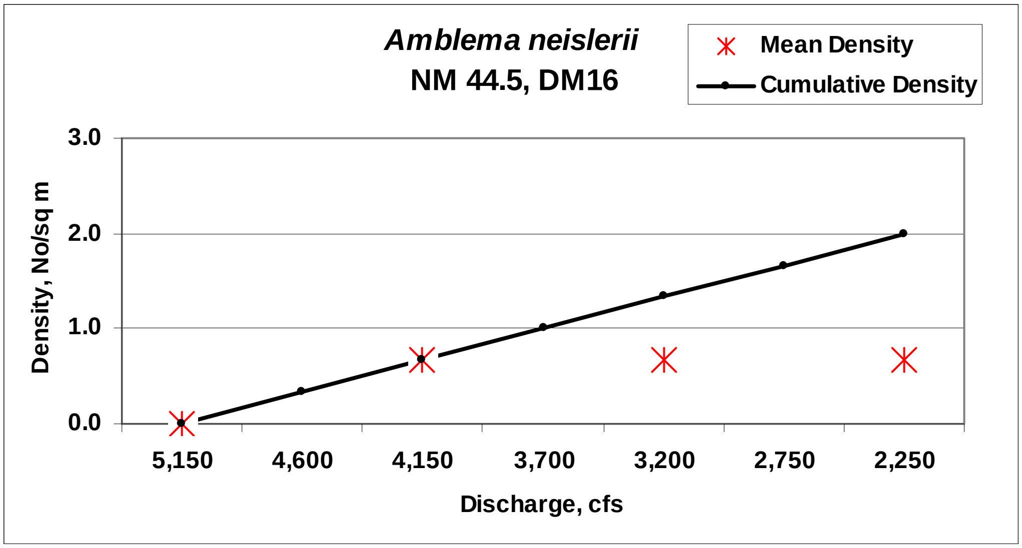

Figure B17

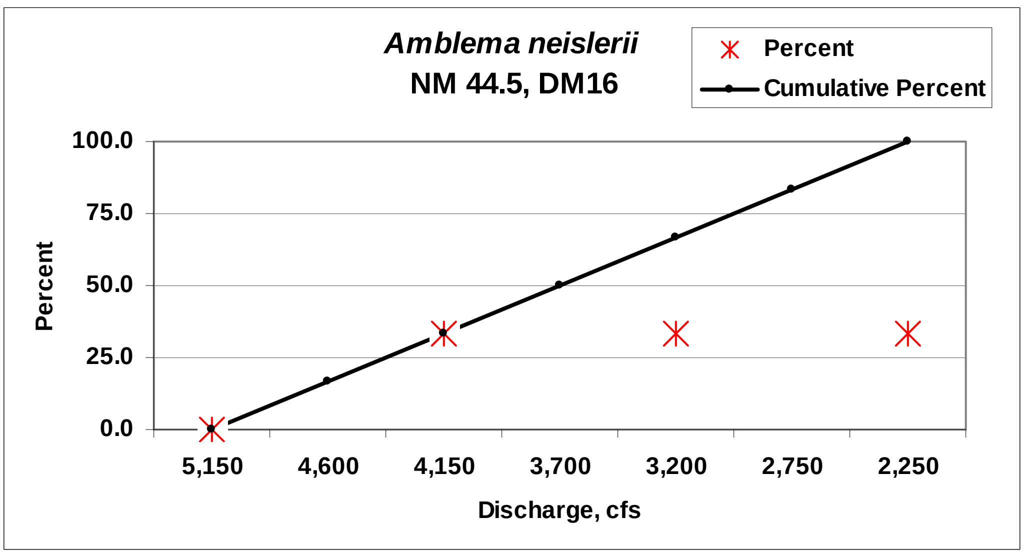

Figure B18

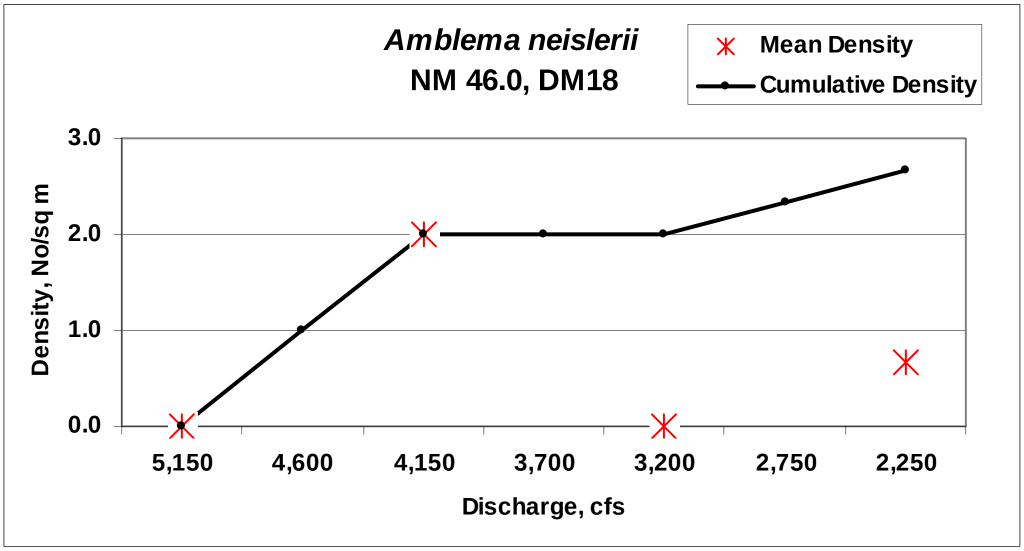

Figure B19

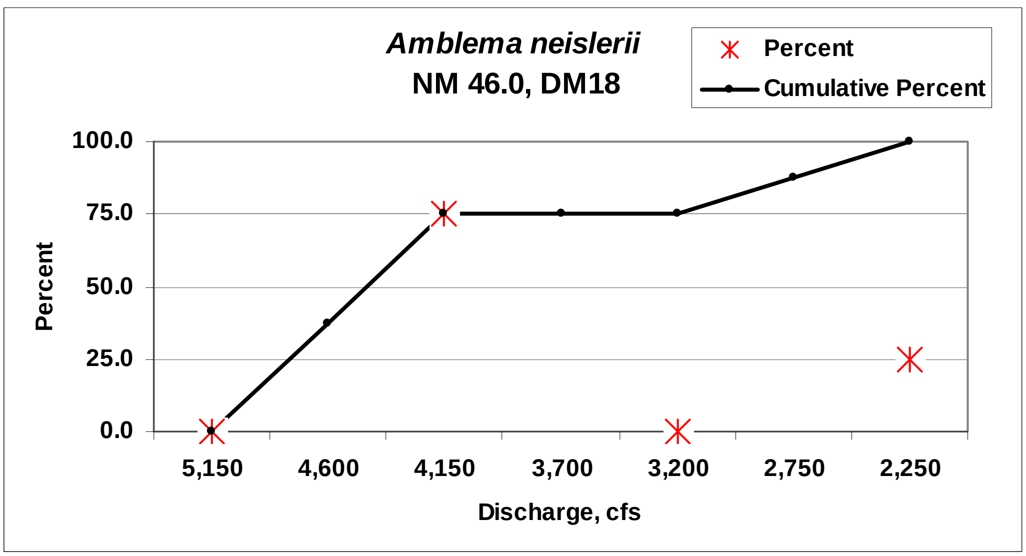

Figure B20

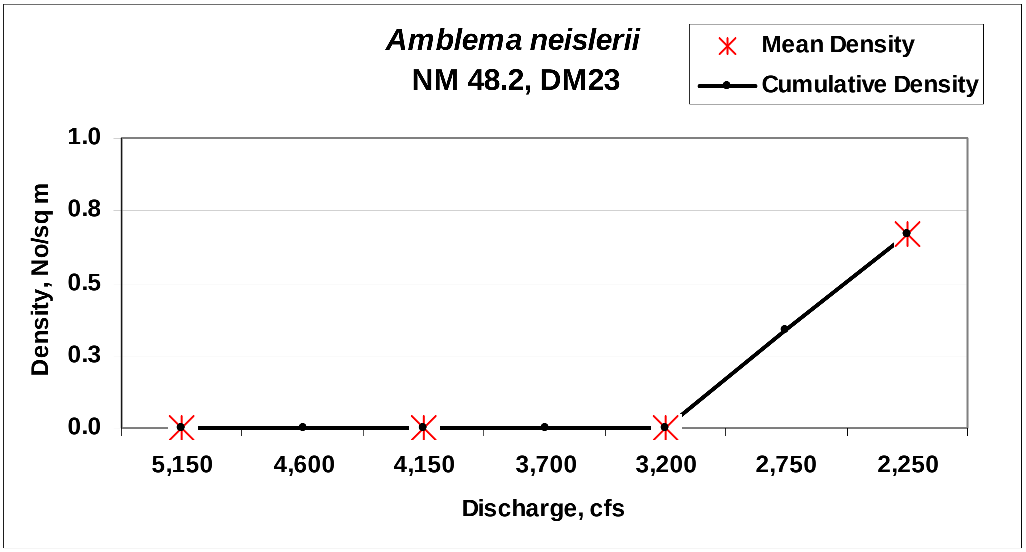

Figure B21

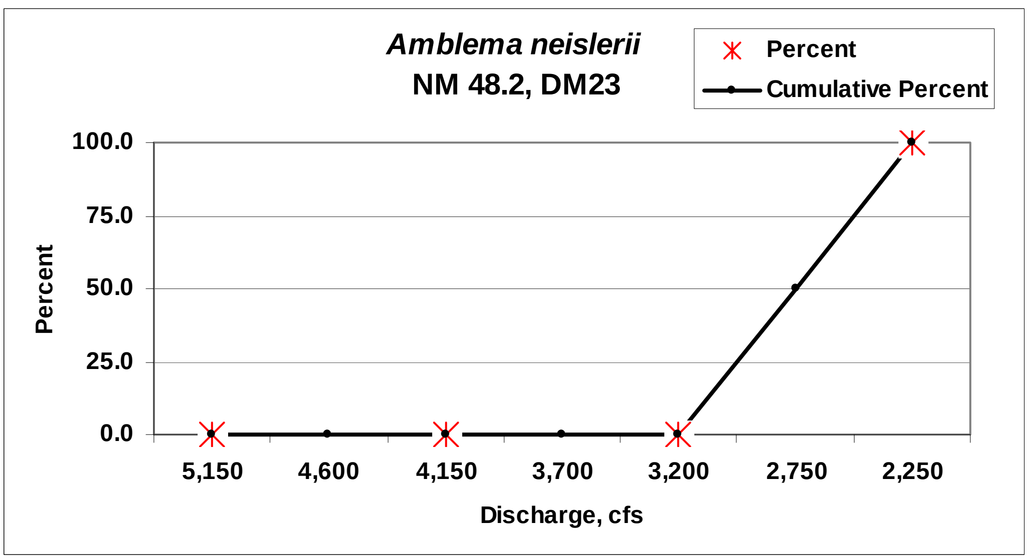

Figure B22