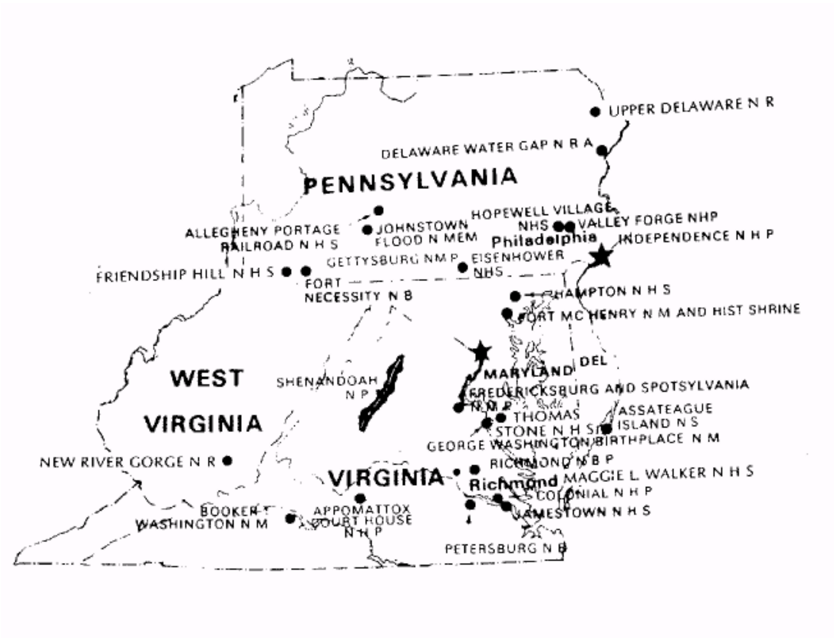

MID-ATLANTIC REGION

RESEARCH/RESOURCES MANAGEMENT REPORT

U.S. DEPARTMENT OF THE INTERIOR

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Department of the Interior

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A BIOLOGICAL SURVEY OF THE NEW RIVER GORGE NATIONAL RIVER

Volume 4
A Survey of Freshwater Mussels

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A Survey of Freshwater Mussels

by

Virginia Cooperative Fish and Wildlife Research Unit

and the

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THE EFFECTS OF FLUCTUATING FLOWS ON MUSSELS AND AQUATIC INSECTS

INTRODUCTION

The construction and operation of dams for the control and use of flowing waters has been a part of human civilization for thousands of years. The benefits of this practice such as flood-control, irrigation, increased water supply, and hydroelectric power-generation are obvious. However, only in the latter half of this century has society become aware of the detrimental effects of such water manipulation. Of major importance are the effects of dams on the aquatic environment downstream of impoundments. The downstream biota is impacted through alterations in the abiotic components of the system including the flow regime, sediment load, water temperature, and water quality (Petts 1984). Changes in these factors lead to alterations in channel form, habitat suitability, and primary production, which directly affect invertebrate and fish community stability and function.

The type and magnitude of impacts on the fauna below an impoundment vary with the purpose and operation of the dam. The general effects of dams on the fauna and ecology downstream have been thoroughly reviewed (Baxter 1977; Langford 1983; Walburg et al. 1981a; Petts 1984). These reviews have dealt mainly with impacts on fish and aquatic insects. This paper will address the potential impacts of hydroelectric power-generation dams on freshwater mussel (Unionidae) populations downstream. There is a paucity of information on the effect of hydroelectric dams on downstream mussel faunas specifically, but the wealth of knowledge available on the impacts on aquatic insects provides insight into the possible consequences for mussel populations. Being sedentary filter-feeders, mussels are susceptible to many of the same problems experienced by other macroinvertebrates with similar life styles. Due to the lack of specific information on mussels, many of the inferences drawn in this paper will be based on known impacts on other macroinvertebrates.

POTENTIAL IMPACTS ON MUSSELS

A variety of habitat alterations are associated with hydroelectric power-generation (Walburg et al. 1981b; Petts 1984; Cushman 1985). Of importance to mussels are changes in substrate type and stability. Waters released from hydroelectric dams are often clear and free of sediment due to the settling out of materials within the reservoir. Clear-water discharges coupled with extreme fluctuations in flows may be extremely erosive and cause rapid degradation of the river bed and banks (Baxter 1985). Fine sediments are transported downstream and deposited, thus altering habitats not directly impacted by alterations in flow. Changes in current velocities and substrates, along with increases in suspended solids, can devastate invertebrate populations by interfering with critical life history stages (Lehmkuhl 1979; Petts 1984). The settling out of silts and other fine particles over mussel beds can lead to elimination of mussels through interference of gill functioning and the creation of unsuitable substrates (Fuller 1974). Sickel (1982) cited high silt loads, associated with extreme daily fluctuations in discharge through Barkley

Dam, Kentucky, as a possible contributing factor to poor recruitment of most mussel species below the dam. The erosional forces of increased flows may also damage the shells of mussels and ultimately affect mussel survival.

Scouring of the river bed caused by increased discharge volume and velocity can cause dislodgement and shifting of gravel and other coarse sediments. Since these substrates, in conjunction with moderate current velocities, provide ideal mussel habitat, removal or disturbance of gravels and other bottom materials can result in the destruction of mussel beds (Fuller 1974; Sickel 1982). Scouring may also eliminate aquatic macrophytes, resulting in unstable environments that are unsuitable for habitation by most aquatic invertebrates (Lehmkuhl 1979; Walburg et al. 1981b).

Excessively high current velocities alone may be detrimental to invertebrate populations due to dislodgement of individual organisms (Radford and Hartland-Rowe 1971; Trotzky and Gregory 1974; Matter et al. 1983). Only organisms highly specialized for torrential conditions are able to maintain large populations in waters with high current velocities (Ward 1976). In areas experiencing extreme fluctuations in flows, the fauna may become dominated by those species that can rapidly migrate into the substrate (Petts 1984). Thus, some species of mussels would be subject to dislodgement from the substrate and physical transport downstream. Such conditions could lead to the elimination of affected species from a given stretch of water.

Peaking power flows may subject mussels and other invertebrates to periods of stranding and desiccation. Fisher and LaVoy (1972) observed that a freshwater "intertidal" zone was created by water level fluctuations below a dam on the Connecticut River. Along a transect from the low to high water mark within this zone, density and diversity of benthic invertebrates decreased markedly. Community composition shifted from mollusc predominance on the least exposed sites to chironomid-oligochaete predominance on the most exposed sites. Much of the change in biomass along the transect was attributed to the intolerance of unionid molluscs to exposure.

Changes in water quality resulting from releases of hypolimnetic waters can have adverse consequences on the benthos of the receiving stream. Lack of a diverse benthic fauna below many impoundments in the Tennessee Valley has been attributed to seasonally low oxygen tensions of hypolimnetic releases (Isom 1971). Relatively high concentrations of hydrogen sulfide, iron, and manganese associated with anoxic hypolimnial releases have been identified as causes in faunal depletions below some dams (Petts 1984). Conversely, nutrient concentrations may be elevated in hypolimnial releases, and increased calcium/sodium ratios may favor reproductive success and ionic regulation in freshwater molluscs (Petts 1984).

Hydroelectric power-generation has been shown to affect feeding and growth of aquatic invertebrates (Radford and Hartland-Rowe 1971; Lehmkuhl 1972; Petts 1984). Deep release dams may not provide an adequate supply of food for development or maintenance of a fauna that is dependent on micro-seston. Mussel growth may be impaired as a result of their remaining closed and not feeding for extended periods in response to high silt loads or poor water quality (Fuller 1974).

Although power-generation releases may substantially impact mussel populations through alteration and degradation of habitat, of possibly far greater importance are their potential consequences to mussel reproduction and recruitment. Nearly all freshwater mussel species use specific fish species as glochidial hosts in order to complete their life cycles (Fuller 1974). Alterations of fish habitat or fish behavior may disrupt these fish/mussel associations. Anthropogenic changes in fish faunas have been identified as one of the major threats to mussel populations (Fuller 1974). Operational procedures of hydroelectric power dams can have significant consequences for downstream fish populations by altering spawning conditions, eliminating prey items, providing flow and depth conditions unsuitable for certain life history stages, and displacing and/or stranding individual fish (Radford and Hartland-Rowe 1971; Lehmkuhl 1979; Walburg et al. 1983; Petts 1984). Thus, fish faunas below hydroelectric dams are often characterized by extirpation of some species, and changes in faunal composition, biomass and diversity. Loss of potential fish hosts can lead to reproductive failure of mussels and may be a cause of poor mussel recruitment below dams producing extreme fluctuations in discharge (Sickel 1982).

Dam operations may impact mussel reproduction in a second way by altering the thermal regime below impoundments. Hypolimnial discharges dampen natural seasonal and diurnal variations in temperature producing depressed summer and elevated winter temperatures (Lehmkuhl 1972; Baxter 1977). Thermal constancy and seasonal temperature patterns below deep-release reservoirs may not provide the thermal stimuli necessary for completion of some invertebrate life cycles (Lehmkuhl 1972; Matter et al.

1983). Temperature is a major determining factor in mussel spawning and subsequent glochidial development and discharge (Yokley 1972; Fuller 1974). Dampening of thermal variations may result in disruption of spawning cycles and/or failure of glochidial release or release under unfavorable conditions. Low temperatures will affect glochidial response to host contacts which may result in lower recruitment rates (Fuller 1974). The loss of mussel populations below Tims Ford Dam and Norris Dam in Tennessee has been attributed to depressed spring and summer water temperatures resulting from hypolimnial releases (Steve Ahlstedt, Tennessee Valley Authority, pers. comm.).

The effects of altered flows on downstream fauna, resulting from hydroelectric power-generation, are related to the pattern of reservoir releases, attributes of the water released, channel morphology, and substrate composition (Petts 1984). Impacts on benthic populations decrease as distance from the dam increases, but faunal depletions have been known to exist for 100 kilometers downstream of hypolimnial release dams (Lehmkuhl 1979). Volume of tributary and groundwater inflow, meteorological influences, and channel morphology help to moderate the effects of discharges and return the environment to a more natural state (Walburg et al. 1983). Downstream response to hydroelectric power-generation will vary according to site characteristics and dam operations, but in general the effect is to produce marked changes in the benthic community through shifts in species diversity and abundance.

SUMMARY

The operation of hydroelectric dams for peak power generation produces a variety of environmental conditions that can adversely affect the survival and maintenance of freshwater mussel populations downstream. Major fluctuations in discharges can alter suitable mussel habitats by creating unstable substrates, increasing silt loads downstream, and scouring the river bed. Increased stream bank erosion and deposition of associated sediments may destroy existing mussel beds or impair recruitment. Elevated current velocities may eliminate invertebrates not adapted for rapid increases in flows, and cause mussels to be dislodged from the substrate and transported to potentially unsuitable habitats. Peaking power flows may subject mussels to periods of stranding and desiccation, effectively eliminating most species from periodically exposed sites.

Changes in downstream water quality are also associated with hydroelectric dams. Seasonally low dissolved oxygen levels below some dams have led to the elimination of mussels and other invertebrates. Mussel populations may also be adversely affected by relatively high levels of hydrogen sulfide, iron, and manganese associated with anoxic hypolimnial releases. Mussel growth may be inhibited through changes in food supply and feeding behavior in response to altered flow regimes or poor water quality.

A major concern involving mussels and hydroelectric power-generation is the potential impact on mussel reproduction and recruitment through alterations in the fish fauna, fish behavior, and the thermal regime for

spawning. Extirpation or reduction of available fish hosts can severely limit mussel recruitment and ultimately lead to elimination of affected species. Conditions of thermal constancy produced by hypolimnial releases may alter mussel spawning cycles and glochidial release periods. Dulled glochidial response associated with altered thermal regimes may also impair recruitment.

The type and magnitude of environmental impacts realized below a hydroelectric dam will be related to the pattern of reservoir releases, quantity and quality of water released, channel morphology, and substrate composition. Downstream effects decrease with increasing distance from the dam and are moderated by tributary and groundwater inflows, meteorological factors, and channel form. Negative impacts to mussel populations associated with altered flow regimes will vary depending on local conditions, but at least some shifts in species abundance and diversity can be expected.

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INTRODUCTION

The freshwater mussel fauna (Unionidae) of the New River has been sampled periodically throughout this century, beginning with a cursory survey conducted by A. E. Ortmann shortly after 1900 (Ortmann 1913). Since then, there have been at least six other mussel surveys conducted along some portion of the New River drainage (Jirka and Neves 1985). Despite the relatively frequent collection of mussels in this river, there is a paucity of information concerning the naiad fauna of the stretch of river designated as the New River Gorge National River (NRGNR). This national park includes the portion of the river from Hinton, West Virginia at New River Mile (NRM) 63 to just downstream of Fayetteville, Vest Virginia (NRM 11). The lack of surveys in this area is mainly a result of the relative inaccessibility of this part of the river. Those surveys that have included sites within the Park were by no means exhaustive, and the majority of the gorge has remained virtually unexplored with respect to the mussel fauna.

This report presents the results of an extensive mussel survey conducted from June 19S4 to September 1985 throughout the 52-mile stretch of the New River located within the NRGNR. Objectives of the survey were as follows: identification of areas containing dense mussel assemblages, general descriptions of mussel habitat within these areas, and determination of mussel species composition and species densities within the Park. A further objective of the survey was to determine whether the federally endangered pink mucket (*Lampsilis orbiculata*), was present in the Park, since live individuals of this species have been found recently below Kanawha Falls, 2.0 kilometers downstream of the mouth of the New River (Stansbery 1980; Clarke 1982; Taylor 1983).

METHODS

Qualitative sampling for mussels began in June 1984. A preliminary reconnaissance aimed at locating important mussel beds and habitats within the Park was made by floating the river by raft, walking accessible areas of the bank, and questioning local landowners about the whereabouts of mussels within the various sections of the river. River reaches having potentially suitable habitats or high concentrations *of* mussels were recorded on maps and singled out for more intensive qualitative sampling.

Qualitative sampling of selected areas consisted of searching for mussels by snorkeling, hand-picking, use of waterscopes, and sorting of muskrat middens to determine species present. Most areas were snorkeled for 0.5-1.0 hour by three or four individuals, and shells and live specimens were identified and counted to determine species composition and relative abundance of naiades at each site. Work on this segment of the study was completed in September 1984.

Based on findings of the qualitative sampling, eleven sites were chosen for general habitat description and quantitative sampling to assess mussel densities. Criteria used in selecting these sites included species diversity, overall mussel abundance, uniqueness of habitat type, and location within the Park. An effort was made to locate study sites throughout the length of the Park to record changes in habitats and species densities associated with different reaches of the river.

General habitat descriptions such as substrate type, current velocity, and presence and percent cover of aquatic vegetation were made for each mussel bed. Bottom substrate was classified by dominant, subdpminant, and minor components of the river bed. Categories of substrate included sand (<0.2 cm diameter), gravel (0.2-5.0 cm), cobble (5-25 cm), small boulder (25-50 cm), large boulder (>50 cm), and bedrock. Current velocities (velocity at 0. 6 x depth) were recorded at each major bed using a pygmy current meter. Velocities were recorded along three or four evenly spaced transects perpendicular to current flow. Three water velocities were taken along each transect; left side of the bed, center, and right side. All velocity measurements were taken at summer low flow conditions during August and September 1985. In beds containing aquatic macrophytes, plants were identified to species, and percent cover by species was visually estimated.

Quantitative sampling of mussels was conducted using two techniques. Initially, a 0.5 m quadrat sampler was to be used to estimate mussel • densities in major beds. However, it was not feasible to adequately sample all of the beds in this manner due to their extensive size or the presence of deep water, swift currents or large boulders. Therefore, an alternate method using snorkeling transects was used instead of quadrats. This method consisted of laying a plastic tape of known length along the river bottom parallel to the current. Densities (No. of mussels/m^2) along the transect were determined by snorkelers identifying and counting all mussels within one half meter of each side of the tape and dividing the total by the length of the tape in meters. Two snorkelers were used on all transects, with each snorkeler counting the mussels on his respective side of the tape. Presence of empty valves of the various species was also noted. The length and number of transects used on each bed varied with the dimensions of the bed, but in general at least six transects 50 meters in length were used on most beds. Densities from transects in the same bed were averaged to estimate mean mussel density for the bed.

Transects were established using a stratified random sampling design, in an effort to ensure that the different habitats within a bed were sampled in proportion to their area within the bed. Some areas of certain beds could not be sampled due to extremes in depth (<0.25 or >2.0 m) or time constraints involved in sampling exceptionally large beds. However, at least 300 m were sampled in all beds greater than 200 m in length, and areas chosen for sampling were believed to be representative of most of the bed.

As a check on the accuracy of density estimates derived using transects, mussel densities were estimated using a 0.5 m quadrat sampler in three beds in which transects were also used. This sampling was done to determine whether any mussels were being overlooked and not counted by snorkelers swimming the transects. Quadrat sampling involved the removal of all substrate within the quadrat to a depth of 15 cm. All mussels within the quadrat were identified and counted to obtain estimates of mussel densities by species. Using this technique, it is unlikely that any individuals were not counted. A total of 25 quadrats were taken at each bed, and an attempt was made to locate quadrats along the original transect lines to allow for comparison of the two methods. A Wilcoxon signed rank test was used to test for differences in densities estimated by the two methods.

SITE DESCRIPTIONS

The locations of mussel beds chosen for quantitative sampling and habitat description are given on Figures 3.1-3.9, and general descriptions of each site are given below.

MB 1 - located on river left (looking downstream) between NRM 60-61 in the lower end of the pool below Tug Creek. Dimensions: 120 x 35 m. Depth: 0.2-1.4 m.

MB 2 - Consists of a series of closely spaced, but unique, beds located on river right between NRM 60-61 among the four islands upstream of Brooks Branch. Three distinct mussel beds in this area received quantitative sampling and habitat description and were treated separately.

2a. - located in the run between the first and second islands (the two farthest upstream). Dimensions: 35 x 8 m. Depth: 0.2-0.7 m.

* - Dimensions are only approximate due to the irregular shape of most beds.

2b. - located in the run between the third and fourth islands and along the main channel side of the lowest island. Dimensions: 40 x 9 m. Depth: 0.1-1.3 m.

2c. - located in the run between the third island and the right river bank. Dimensions: 35 x 15 m. Depth: 0.2-0. 7 m.

MB 3 - located between NRM 58-59 on river left in the run between the bank and the upper end of Brooks Island. Dimensions: 170 x 55 m. Depth: 0. 3-2. 0 m.

MB 4 - located between NRM 57-58 on river left along and below the lower end of Brooks Island. The upper end of the bed consists of a run, and the lower half is in a pool. Dimensions: 250 x 75 m. Depth: 0.2-1.5 m.

MB 5 - located between NRM 53-54 on river right between Laurel and Lick Creeks. The upper end of the bed is in a pool, and the lower end is in a run above a large rapid. Dimensions: 210 x 70 m. Depth: 0.1-0. 8 m.

MB 6 - located between NRM 52-53 on river left, 100 m below the Interstate-64 bridge. The bed extends from the riffle downstream into the pool along the large island and between the island and the left river bank. Dimensions: 440 x 90 m. Depth: 0.1-2. 0 m.

MB 7 - located between NRM 47-48 on river left in the pool below Camp Branch. Dimensions: 80 x 20 m. Depth: 0.3-0.8 m.

MB 8 - located between NRM 45-46 on river left below the old railroad trestle at Glade. The bed begins in a pool and extends downstream into the run above Glade Creek. Dimensions: 415 x 90 m. Depth: 0.7-2.5 m.

MB 9 - located between NRM 38-39 on river right above Piney Creek. The bed extends from the lower end of a pool into the run above Piney Creek. Dimensions: 270 x 55 m. Depth: 0.3-3.0 m.

MB 10 - located between NRM 31-32 on river left. The bed extends from the lower end of a pool downstream to the rapids above Slater Creek. Dimensions: 260 x 35 m. Depth: 0.3-1.6 m.

MB 11 - located between NRM 22-23 on river right. The bed is in the large pool above Fire Creek, approximately one mile upstream of the creek mouth. Dimensions: 275 x 20 m. Depth: 0.3-2.0 m.

RESULTS

Faunal Description

Dense mussel assemblages were located throughout most of the Park (Figures 3.1-3.10). Live mussels were found in all reaches of the river from Hinton (NRM 63) downstream to Sewell (NRM 19). The majority of the mussel beds exist in the upper third of the Park, and their abundance decreases markedly downstream of Glade Creek (NRM 45). No living or dead mussels were found downstream of the large pool at Sewell.

Seven species of mussels were collected alive during the survey, and two empty valves of an eighth species, *Lasmigona subviridis* were also found (Figures 3.11-3.18; Table 3.1). *Actinonaias carinata* was by far the dominant species within the Park, comprising over 90% of the mussel fauna and being present everywhere mussels were found. *Cyclonaias tuberculata* and *Elliptio dilatata* accounted for almost four and two percent of the fauna, respectively, and were present in all of the major beds of the Park. *Tritogonia verrucosa* was relatively common upstream of Sandstone Falls (NRM 55), comprising over two percent of the mussels found in this reach. However, live individuals of this species were never collected below NRM 52.5, and thus comprised less than one percent of the total mussel fauna of the Park. *Lampsilis ovata*, *Lampsilis fasciola*, and *Alasmidonta marginata* were collected infrequently and are considered uncommon throughout the river below Bluestone Dam. No evidence was found to suggest that *L. orbiculata* exists within the Park.

Habitat Descriptions

Substrate composition of the mussel beds varied considerably; however gravel and cobble were the dominant substrates in most instances (Table 3.2). In general, larger substrate types became more prevalent in the lower reaches of the river, though gravel and cobble remained important elements of the river bottom. Sand was a principle component of some beds and was usually found in pool reaches or in areas of reduced current velocities. Much of the sand in these areas was associated with aquatic weed beds that slowed the current, resulting in deposition of fine substrates. Large boulders were of minor importance in a few beds and were of no significance in all others. Silt and bedrock were never appreciable components of the substrate in the major mussel beds.

Current velocities within beds ranged from <0.01 to 0.76 meters/second (m/s) (Table 3.3). Mean current velocities for entire beds ranged from 0. 03 to 0.56 m/s. Low velocities were associated with pool habitats, and the highest velocities were measured in beds associated with islands that diverted water into a relatively narrow channel.

The majority of the mussel beds sampled contained aquatic macrophytes (Table 3.4). Cover of vegetation ranged from 0 to 28% of total bed area. The dominant macrophyte in the river is water star-grass, (*Heteranthera dubia*), and expansive growths of this plant were associated with mussel beds located in runs or near the ends of pools. Pondweed, (*Potamogeton* spp.), and elodea, (*Elodea canadensis*), are also common in the river and were often present in mussel beds. Nearly all mussel beds in the upper third of the Park are vegetated to some extent; however, no aquatic macrophytes were found in beds below Glade Creek.

Mussel Densities

The data used to test for differences in density estimates derived by the snorkeling method and quadrat method are given in Table 3. 5. The Wilcoxon signed rank test indicated that there was no significant difference in density estimates using the two methods (d.f.=ll, p=.19), although quadrat estimates were slightly higher. Since no significant differences were found between the two methods, density estimates from snorkeling transects are assumed to be accurate, and all further reference to mussel densities are to those derived by this method.

Naiad densities in the beds ranged from 2.48 to 13.74 individuals/m (Table 3.6). The highest density was found in MB 9 and the lowest in MB 11. Other beds with notably high densities were MB 2b, MB 5, MB 6, MB 8, and MB 10. No discernible pattern of overall mussel density exists within the Park, though some species show evidence of shifting abundance in some reaches of the river. Densities of *A. carinata* were relatively high in all beds, and empty valves of this species were present at every site. *C. tuberculata* densities were generally low in beds upstream of Sandstone Falls and were highest in beds 6 to 8. Densities of *E. dilatata* were highest in the river upstream of Sandstone Falls, and showed a general trend of decreasing numbers downstream. Valves of this species were present in all beds except MB 2a. *T. verrucosa* was fairly common in most beds above Sandstone Falls, but, except for MB 6, was not collected alive

In any beds below the falls. However, shells of this species were found in every bed except MB 2c. *L*. *fasciola*, *L*. *ovata*, and *A*. *marginata* exhibited patchy distributions and were found in extremely low densities throughout the Park. The highest densities of these species were found in MB 2b. Shells of *L*. *fasciola* and *L*. *ovata* were found in many of the beds where no live individuals of these species were found.

Discussion

The NRGNR supports a healthy, abundant mussel fauna that is relatively low in diversity. Living individuals or remains of eight species were found within the Park, with A. carinata representing over 90% of the fauna. Other relatively common species are C. tuberculata and E. dilatata. T. verrucosa is common only above Sandstone Falls. Large beds of naiades are found from the upstream boundary of the Park, downstream to Sewell in the lower gorge. Mussels are also extremely abundant upstream of the Park to Bluestone Dam, though this section of the river was not included in this study. Mussel colonization of the river downstream of Sewell appears to be precluded by a paucity of suitable habitat and possibly a lack of suitable fish hosts for certain species.

The mussel fauna of the Park varies considerably from the fauna found elsewhere in the New River. Most notable is the dominance of A. carinata within the Park, since this species has never been collected upstream of the mouth of Roundbottom Creek, Summers county, Vest Virginia, above Bluestone Lake (Markham et al. 1980). The dominant species in the river immediately above Bluestone Lake are C. tuberculata and L. ovata (Tolin 1985). Further upstream in Virginia, T. verrucosa, and E. dilatata are also quite common (Dillon 1977). Species reported from the New River drainage that were not recorded in this survey include Anodonta grandis, Toxolasma parvus, Villosa iris iris, and Quadrula quadrula (Jirka and Neves 1985). In 1984, an empty valve of A. grandis was found immediately below Bluestone Dam (R. J. Neves, unpublished records), and another valve of this species was collected near the lower end of Brooks Island, within the Park boundaries (W.A. Tolin, USFWS, pers. comm.). T. parvus has been found in the New River only near its mouth at Gauley Bridge, West Virginia (D.H. Stansbery, Ohio State Museum, unpublished records). The occurrence of O. quadrula in the river near Sandstone Falls as reported by Bates (1979) is questionable since no other record of this species (historic or recent) exists for the New drainage, and this species is more typical of large, slow-flowing rivers containing finer substrates than those found in the New River. V. i. iris has not been found in the New River mainstem, but one specimen was recently reported from the Bluestone River, a major tributary of the New (Tolin 1985).

The relatively low diversity of the mussel fauna within the Park, and in the New River as a whole, is notable when compared with the diversity of naiades (34 species) found in the Kanawha River (Stansbery 1980; Clarke 1982; Taylor 1983). Many factors have been identified as potential causes of the paucity of mussel species in the New, but none have been substantiated. Most of these relate to the river's geologic and climatic past, the presence of physical barriers to dispersal, lack of a diverse fish fauna in the river, and/or stream captures by other drainages (Ross and Perkins 1959; Neves 1983; Jirka and Neves 1985). Physical barriers to upstream dispersal of fish and mussels, particularly Kanawha Falls, have probably had the greatest influence on mussel diversity in the New, considering the number of mussel species found immediately below the falls.

The majority of the mussel species appear to have healthy populations in at least a portion of the Park, and those that are considered rare in the river generally have a broad distribution. It is possible that L. subviridis, of which only two empty valves were collected at NRM 57 and NRM 19, may also have a limited population within the Park, but no live specimens were found to verify this. The same may be true of A. grandis. It is doubtful that the endangered species L. orbiculata lives within the Park since no evidence of its presence was found. Two species, T. verrucosa and L. ovata, appeared to exhibit unexpected distributions, particularly with respect to the numbers and locations of empty valves found. An apparently healthy population of T. verrucosa exists above Sandstone Falls, yet no live individuals of this species were located below MB 6, one mile below the falls. However, numerous shells were found in all beds downstream of Brooks Island, suggesting that T. verrucosa may have once been relatively common throughout the river below Sandstone Falls, but has since declined in abundance. A similar situation exists for L. ovata. Although live L. ovata were collected from several sites throughout the Park, many areas contained numerous empty valves but no living specimens, indicating that L. ovata may have been more common in the river in the recent past.

Substrate type, current velocity, and percent cover of aquatic vegetation in the mussel beds within the Park varied with location, but certain characteristics were common to all beds. All beds had substrates consisting predominantly of gravel and cobble, usually interspersed with small boulders. These small substrates appear necessary to allow naiades to burrow into the river bottom, and also provide a variety of microhabitats suitable for colonization by a number of species.

Current velocities in major mussel beds ranged from <0.01 to 0.76 m/s; however, it should be noted that these velocities were recorded during summer low flows. Velocities at other times of the year may be substantially higher. The range given here is close to the minimum that would be found in these beds, and indicates that at least some of the mussel species in the Park can tolerate extremely low current velocities. The acceptable upper limits of current velocities are not known precisely, but any flows that result in scouring of the river bed and dislodgement of gravel and cobble from the bottom would be detrimental to mussel populations. Mussel beds are limited in number in the lower two thirds of the Park, apparently mainly as a result of the high gradient characteristic of most of this stretch of the river and its effect on substrate composition.

Aquatic vegetation, though not an essential habitat requirement of mussels, is abundant in many areas supporting healthy mussel assemblages. It is notable that most of the aquatic vegetation is found in the upper third of the Park, as are the majority of the mussel beds. In some beds (MB 6, MB 8) markedly high densities of mussels are associated with extensive weed beds. However, it was also observed that mussels did not inhabit areas with extremely thick growths of weeds, particularly those areas in slow or standing water. Apparently, thick beds of vegetation may not allow sufficient water flow through them, and silts and other fine particles settle out creating unsuitable habitat for mussels. Weed beds located in swifter waters may serve to stabilize bottom conditions and trap sand and gravel, creating ideal substrate conditions for many mussel species. The preponderance of mussels associated with aquatic macrophytes may also be related to fish host use of aquatic weed beds. Thus, it appears that aquatic weed beds within the Park are an important habitat component of many mussel beds, and alteration or destruction of this vegetation may lead to changes in mussel species diversity and distribution.

The presence of islands also appears to influence mussel distribution and abundance. Many mussel beds within the Park are adjacent to islands, suggesting that islands create desirable environmental conditions for mussels. Thus, impacts to islands that result in alteration of the surrounding aquatic habitat should be minimized to ensure that mussels in these areas are not eliminated.

Several unique and valuable mussel beds exist within the NRGNR and should be protected to insure the existence of a healthy mussel fauna within the Park. MB 2b, a relatively small bed existing between two islands above Brooks Branch, supports all seven living species occurring in the Park and harbors the highest densities of *A. marginata*, *L. fasciola*, and *L. ovata* located in the Park. MB 4, at the lower end of Brooks Island, is an extensive bed that also contains all seven species, although in relatively low densities. MB 6, MB 8, and MB 9 are the largest mussel beds and three of the most densely populated beds in the Park. The shear size of these beds connotes their value to the stability of the mussel resource in the river.

Mussel beds within the NRGNR are susceptible to a variety of potentially damaging environmental impacts, including extremes in flows, road construction, and water quality degradation. Beds 1, 2, and 6, as well as some of the smaller beds, were partially dewatered during the unusually low flows of August and September 1985. Many mussels in these areas were found stranded several meters from the main river channel. Prolonged periods of extremely low flows could substantially reduce the size of these beds. Construction of the I-64 bridge across the river has resulted in mortality of mussels within MB 6. Scores of empty valves can be found along the left bank of the river below the bridge, and direct mortality of mussels was observed when heavy road-building equipment was driven across the river in this area. Mussels between Laurel and Lick Creeks experience degraded water quality at times due to high silt loads resulting from run-off from road construction activities in the creeks' watersheds. All of these factors may threaten the continued existence of healthy mussel populations within the Park.

In summary, the NRGNR supports an abundant mussel fauna consisting of at least seven, and possibly eight species. Mussel beds exist throughout much of the Park, with the majority of them occurring in the upper third of this river reach. Habitat availability appears to limit the establishment of mussel beds in the extreme lower reaches of the Park and appears to be the cause of the relative scarcity of beds below Glade Creek. Mussels constitute an important part of the benthic community of the river, and steps should be taken to protect this valuable resource wherever possible.

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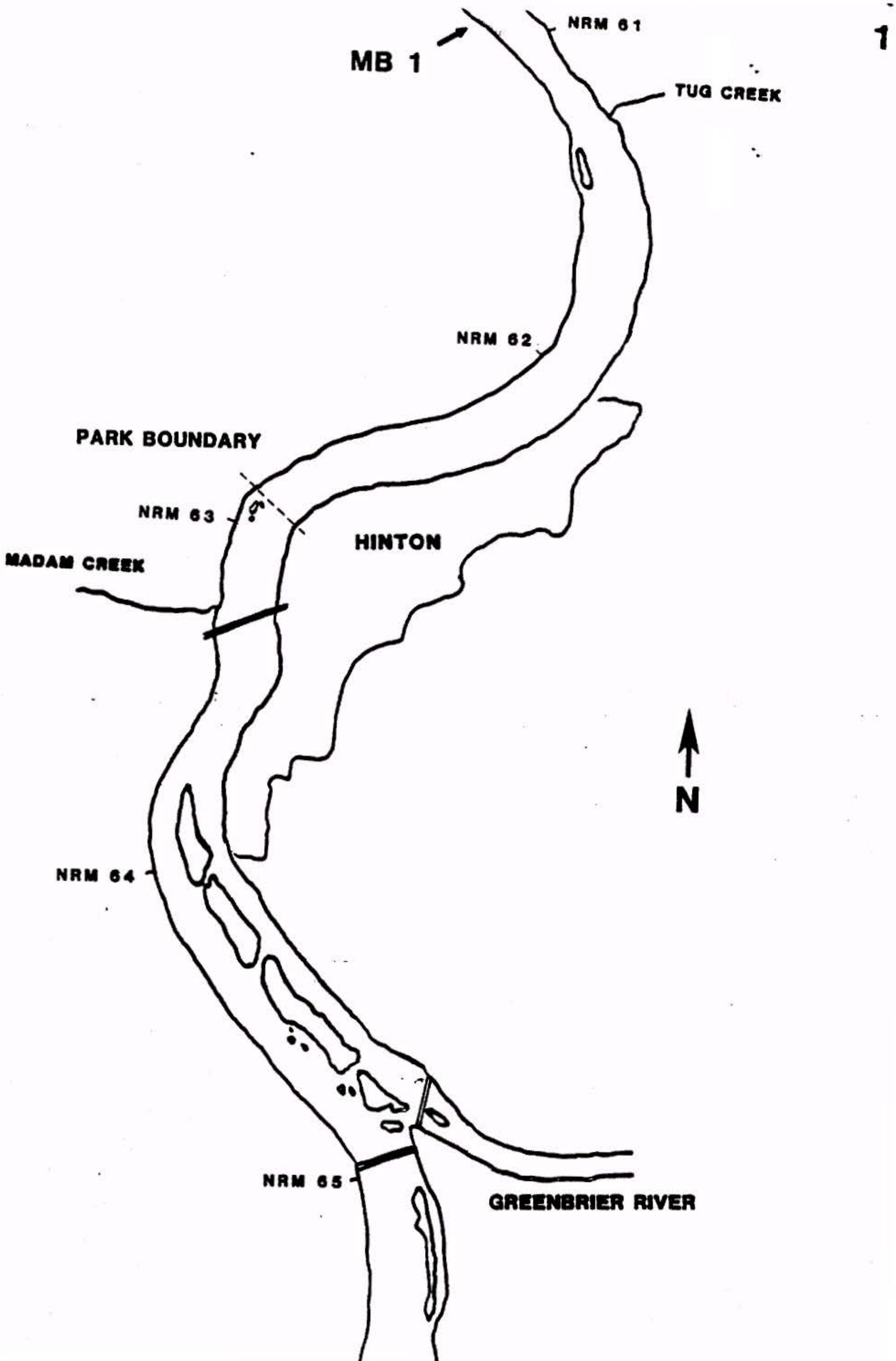
Figures 3.1-3. 10. Mussel beds in the New River Gorge National River.

<u>Key</u>

- dense mussel assemblage

MB # - major bed chosen for extensive sampling

NRM # - New River Mile (miles from river mouth)


NRM 61
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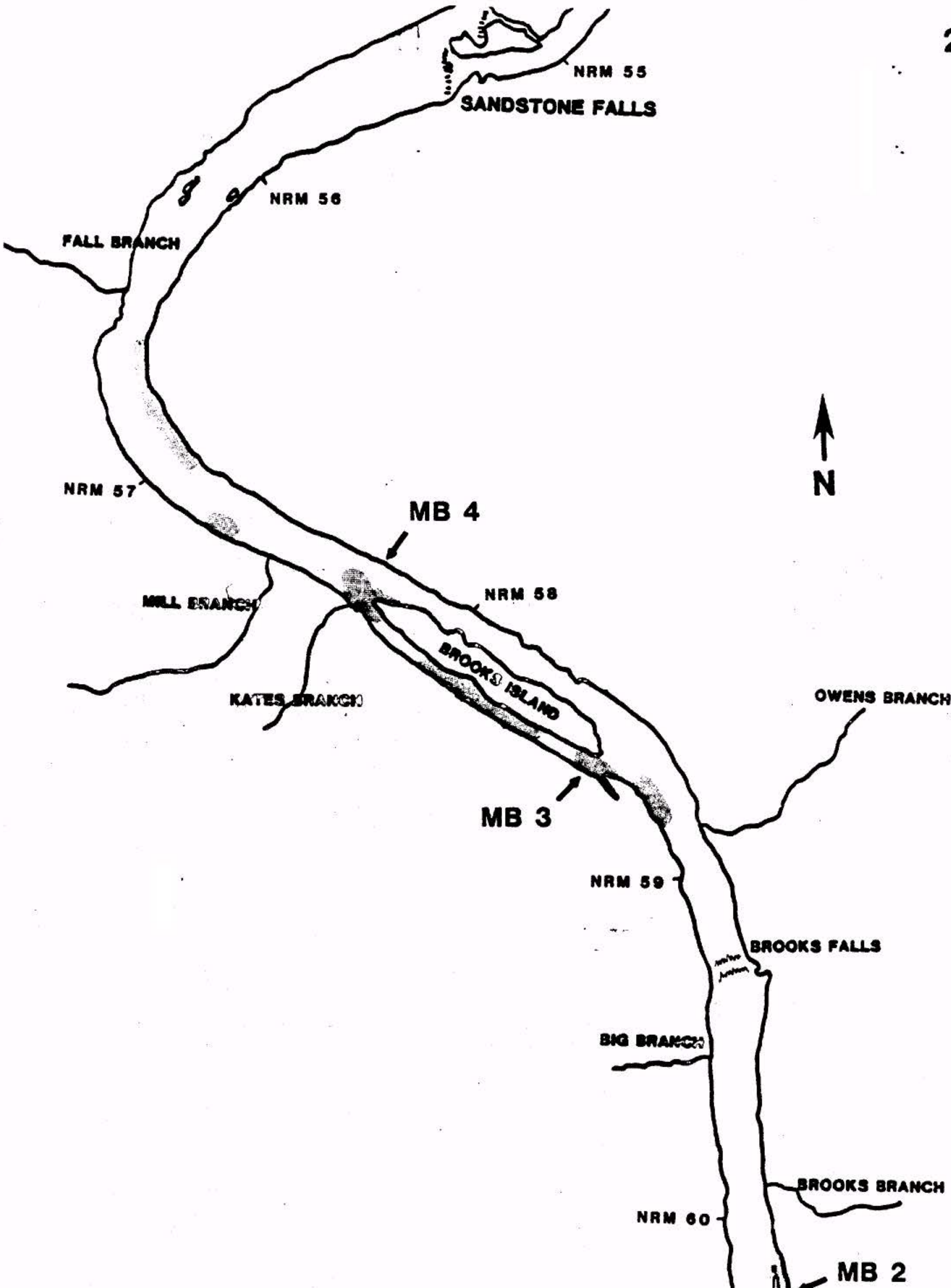
TUG CREEK
NRM 62
PARK BOUNDARY
NRM 63
HINTON
MADAM CREEK
N
NRM 64
NRM 65
GREENBRIER RIVER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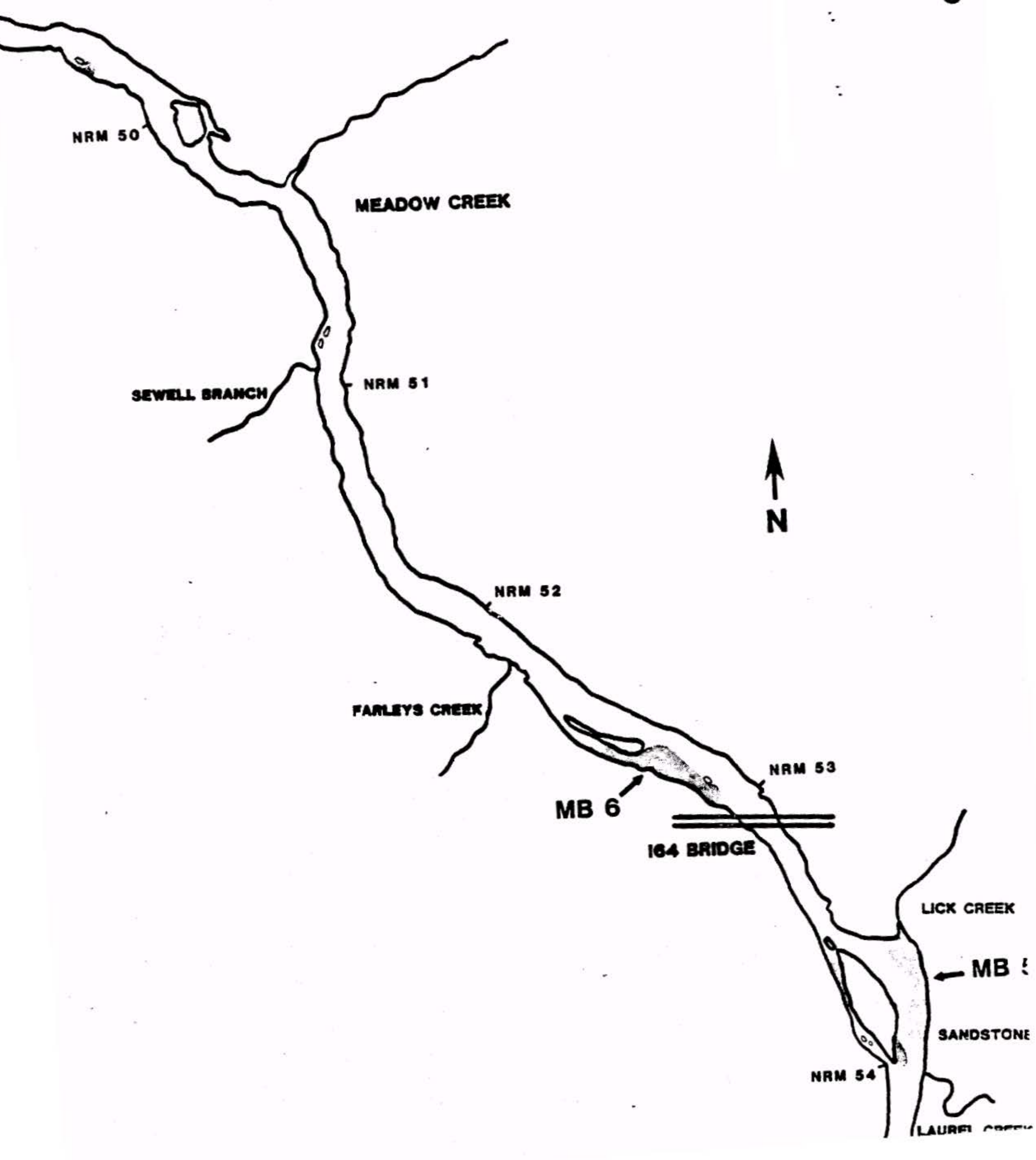
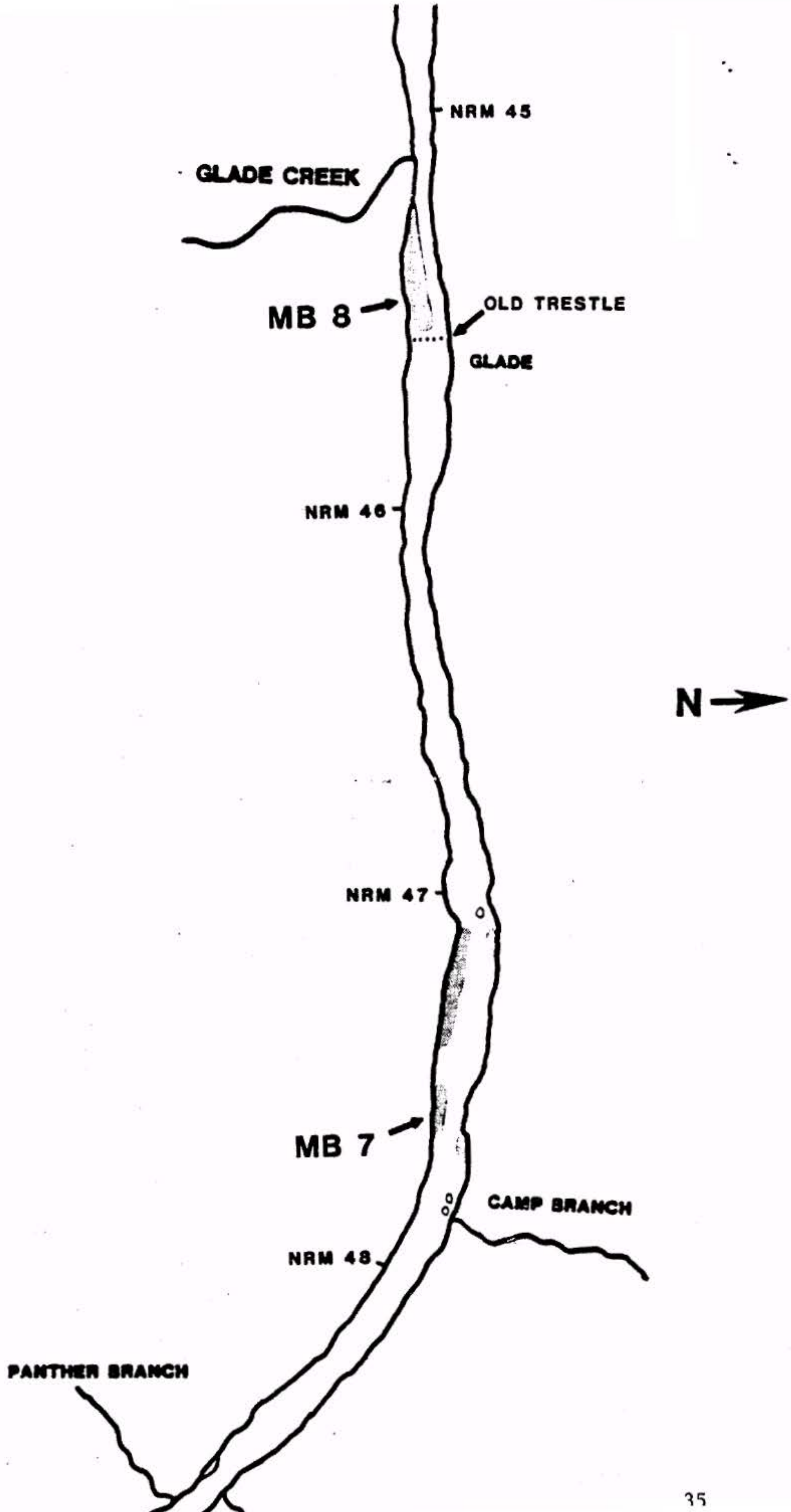
SANDSTONE FALLS
NRM 56
FALL BRANCH
N
NRM 57
MB 4
NRM 58
MILL BRANCH
BROOKS ISLAND
KATES BRANCH
OWENS BRANCH
MB 3
NRM 59
BROOKS FALLS
BIG BRANCH
BROOKS BRANCH
NRM 60
MB 2


NRM 50
MEADOW CREEK
SEWELL BRANCH
NRM 51
N
NRM 52
FARLEYS CREEK
NRM 53
MB 6
I64 BRIDGE
LICK CREEK
MB
SANDSTONE
NRM 54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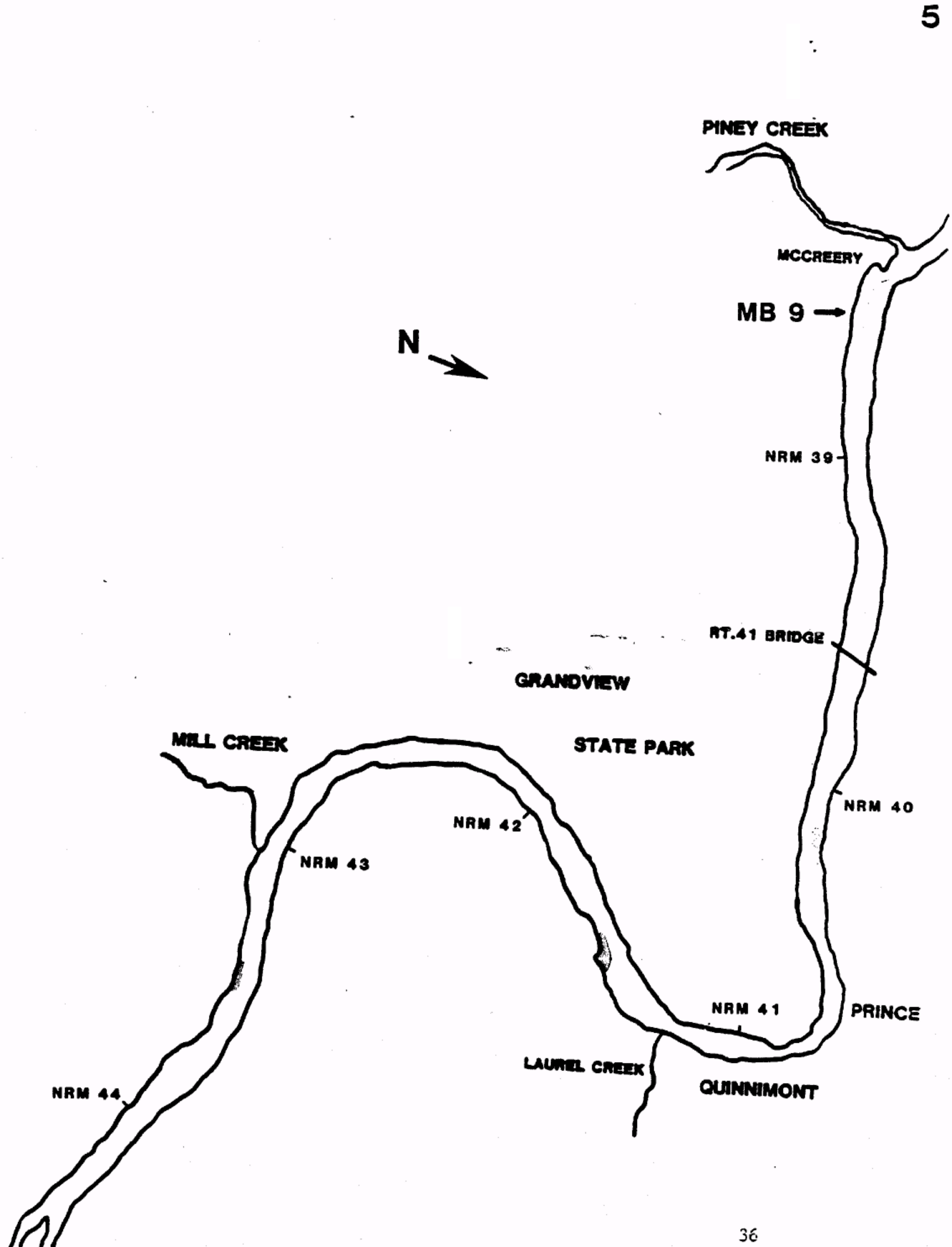
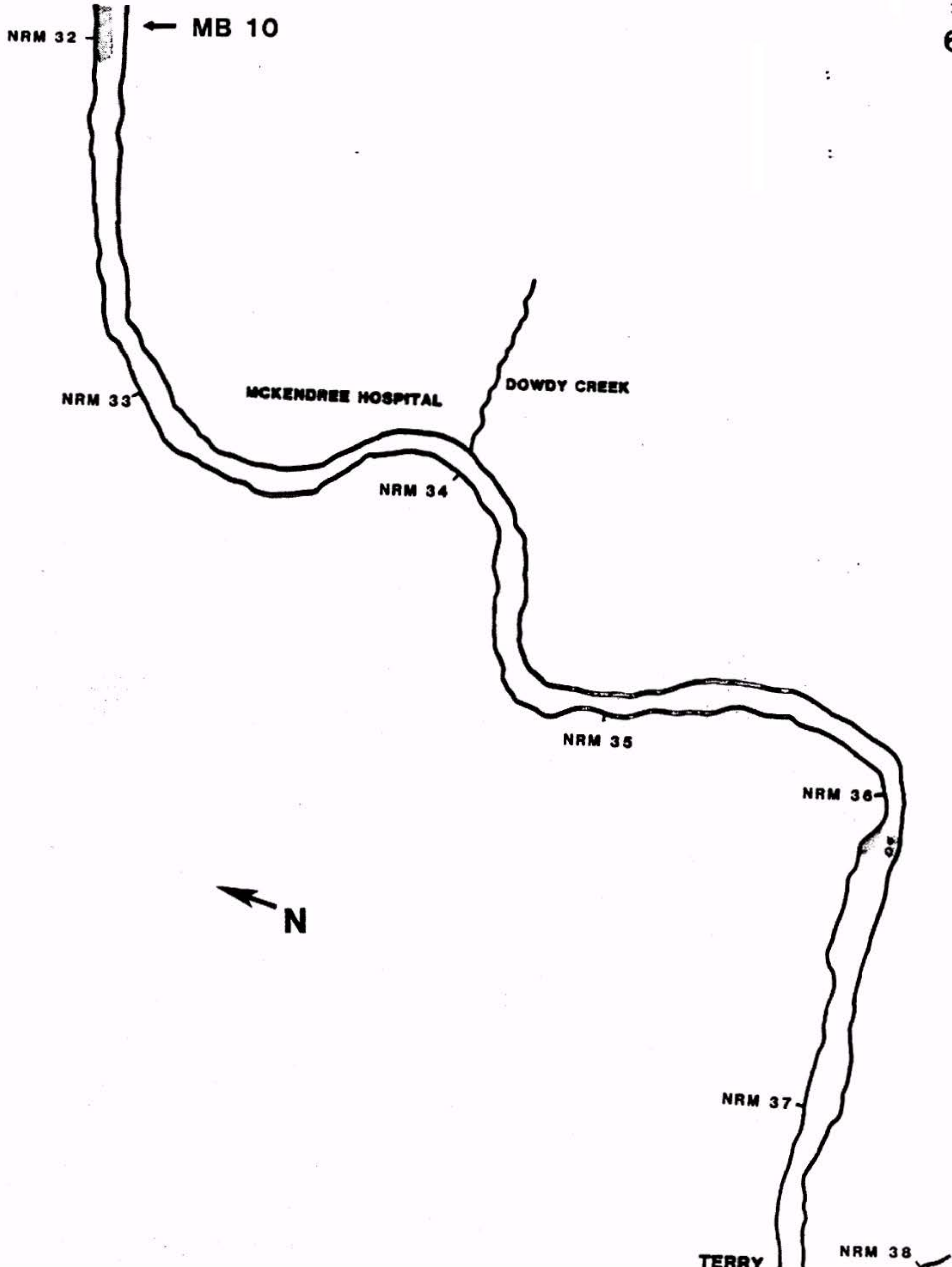
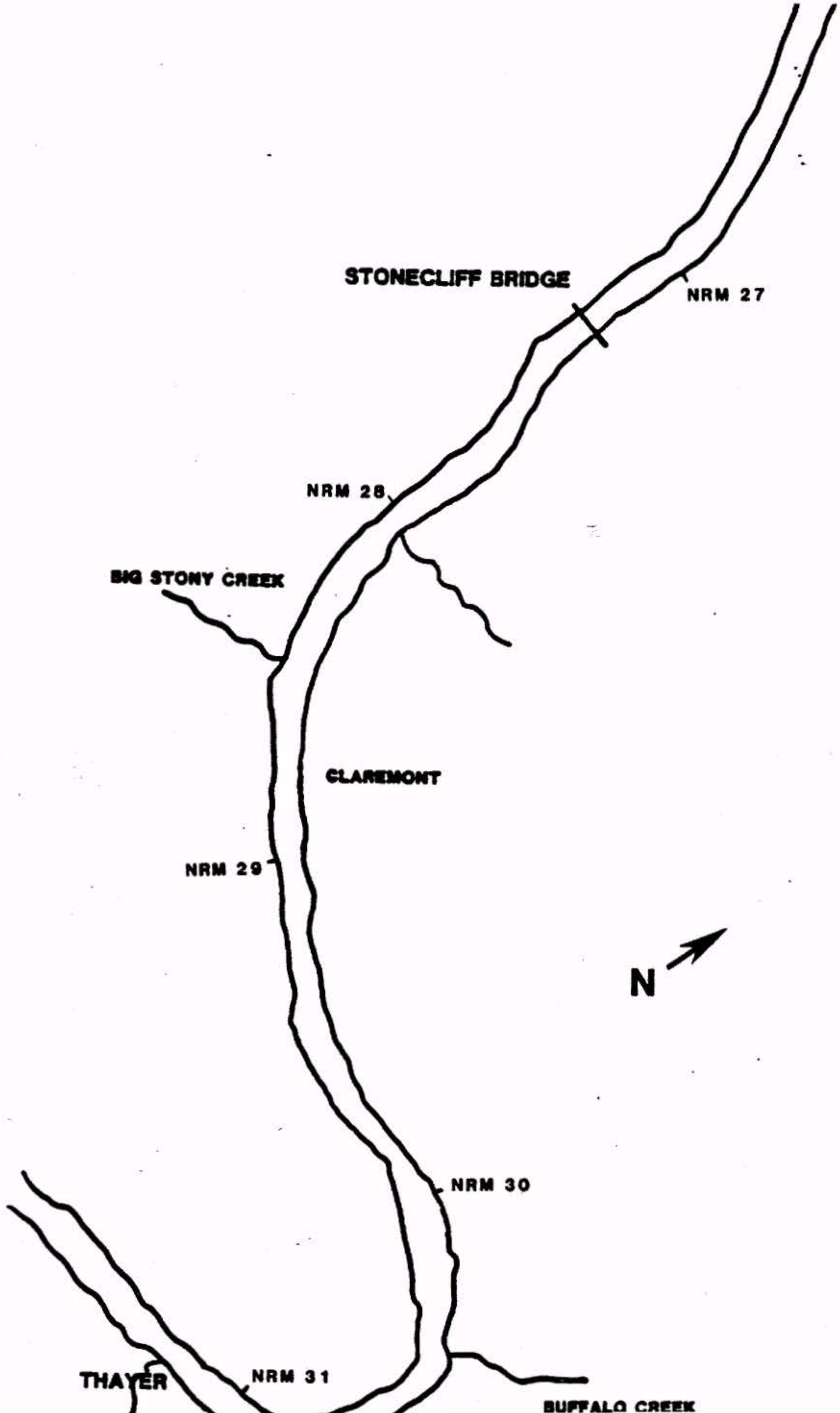
GLADE CREEK
MB 8
OLD TRESTLE
GLADE
NRM 46
N
NRM 47
MB 7
CAMP BRANCH
NRM 48
PANTHER BRANCH


5
PINEY CREEK
MCCREERY
MB 9
N
NRM 39
RT.41 BRIDGE
GRANDVIEW
STATE PARK
MILL CREEK
NRM 42
NRM 43
NRM 40
NRM 41
PRINCE
LAUREL CREEK
QUINNIMONT
NRM 44


NRM 32
MB 10
NRM 33
MCKENDREE HOSPITAL
DOWDY CREEK
NRM 34
NRM 35
NRM 36
N
NRM 37
TERRY
NRM 38


STONECLIFF BRIDGE
NRM 27
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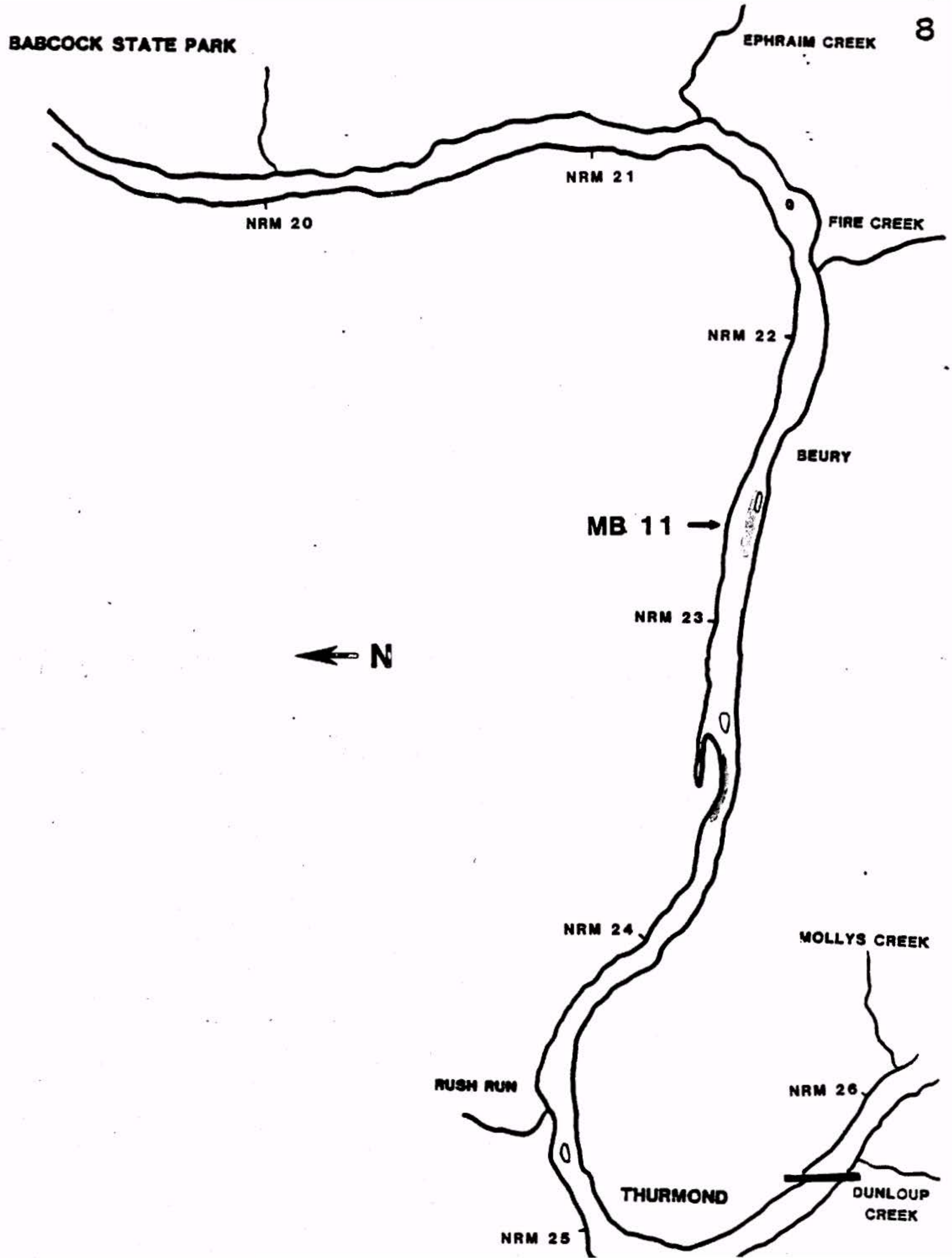
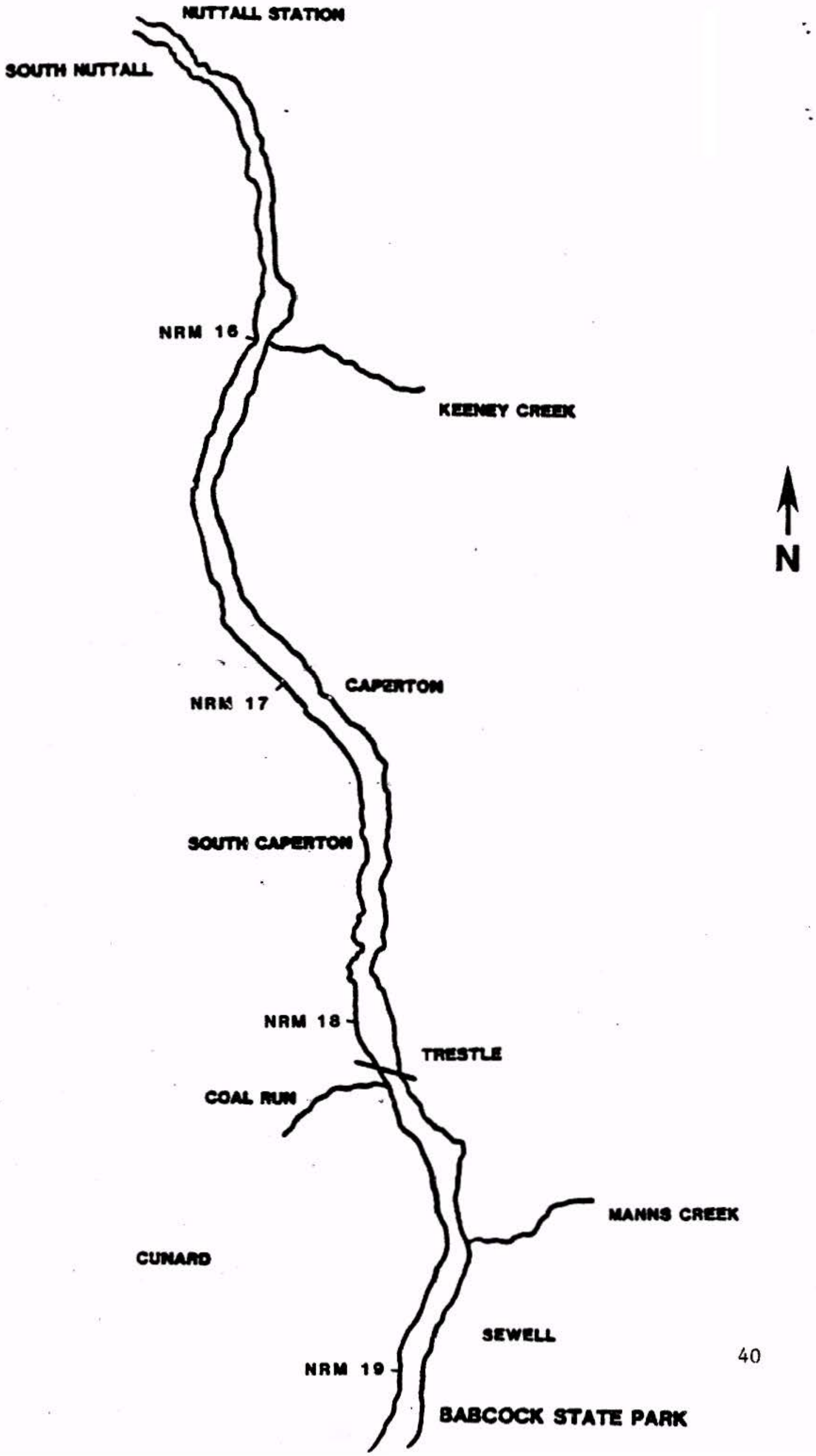
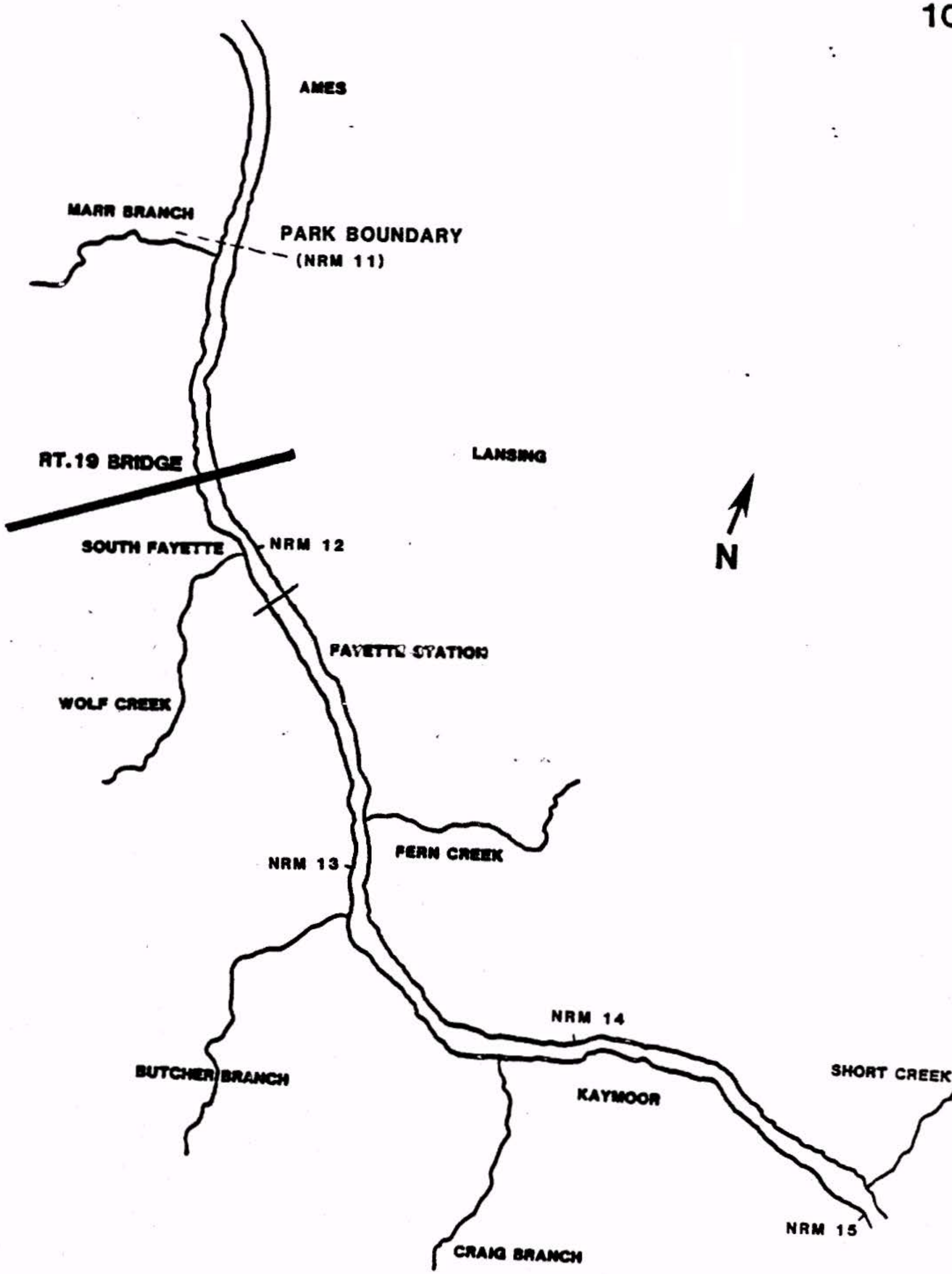
BIG STONY CREEK
CLAREMONT
NRM 29
N
NRM 30
THAYER
NRM 31
BUFFALO CREEK


BABCOCK STATE PARK
EPHRAIM CREEK
NRM 21
NRM 20
FIRE CREEK
NRM 22
BEURY
MB 11
NRM 23
N
NRM 24
MOLLYS CREEK
RUSH RUN
NRM 26
THURMOND
DUNLOUP
CREEK
NRM 25


NUTTALL STATION
SOUTH NUTTALL
NRM 16
KEENEY CREEK
N
CAPERTON
NRM 17
SOUTH CAPERTON
NRM 18
TRESTLE
COAL RUN
MANNS CREEK
CUNARD
SEWELL
NRM 19
BABCOCK STATE PARK


AMES
MARR BRANCH
PARK BOUNDARY
(NRM 11)
RT. 19 BRIDGE
LANSING
N
SOUTH FAYETTE
NRM 12
FAYETTE STATION
WOLF CREEK
FERN CREEK
NRM 13
NRM 14
BUTCHER BRANCH
KAYMOOR
SHORT CREEK
NRM 15
CRAIG BRANCH

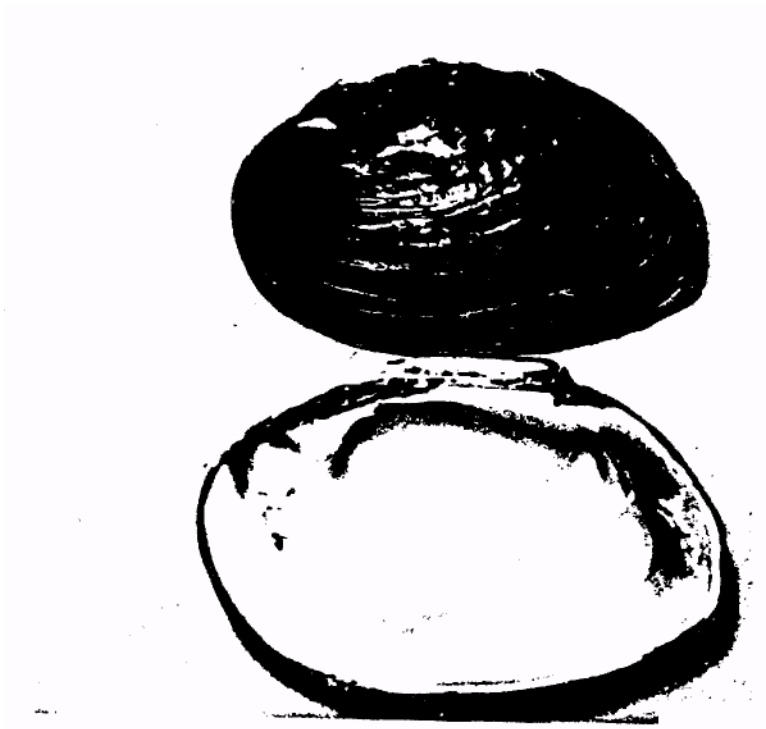


Figure 3.11. Actinonaias carinata (Barnes,1823). Common name: Mucket.

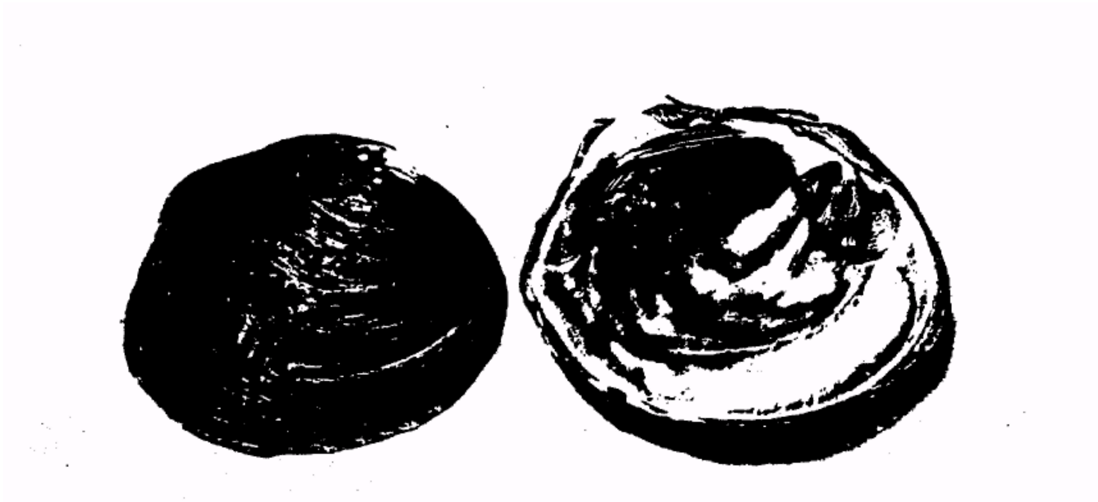


Figure 3.12. Cyclonaias tuberculata (Rafinesque, 1820). Common name: Purple wartyback.

Figure 3.13. Elliptio dilatata (Rafinesque, 1820).
Common name: Spike.

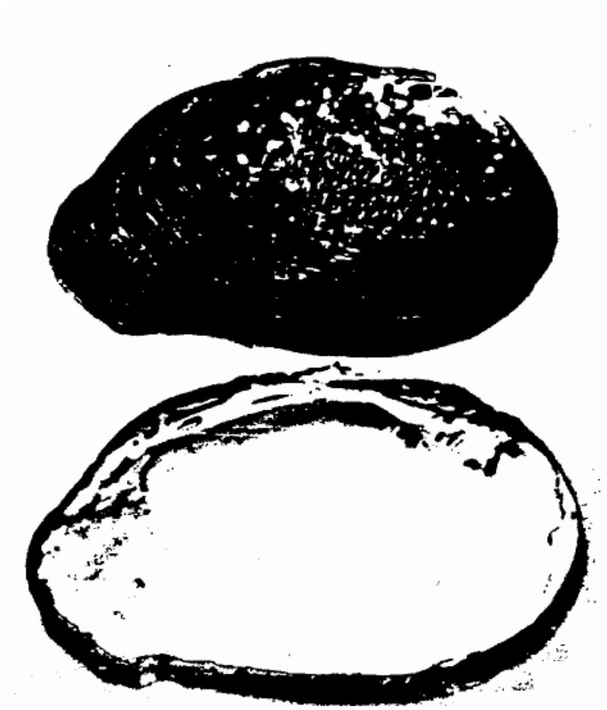


Figure 3.14. Tritogonia verrucasa (Rafinesque, 1820). Common name: Buckhorn.

Figure 3. 15. Alasmidonta marginata (Say, 1818). Common name: Elktoe.

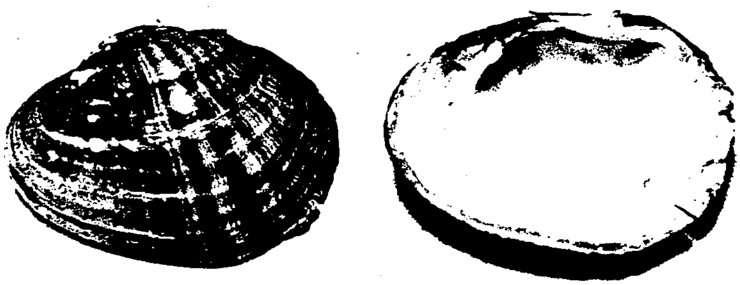


Figure 3.16. Lampsilis fasciola (Rafinesque,1820). Common name: Wavy-rayed lampmussel.

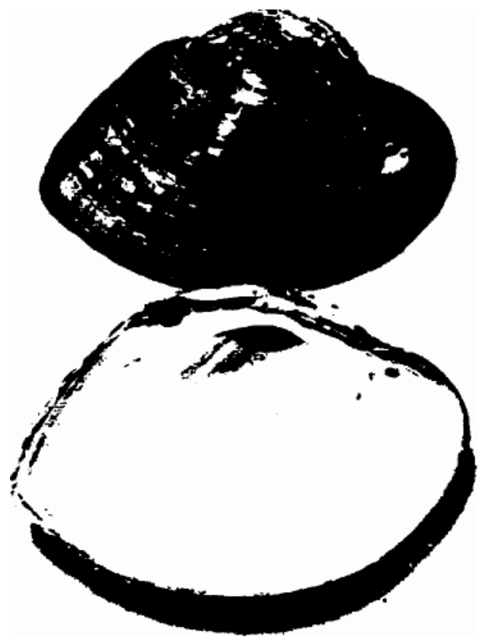


Figure 3.17. Lampsillis ovata(Say, 1817). Common name: Pocketbook.

Figure 3.18. Lasmigona subviridis (Conrad, 1835). Common name: Green floater.

Table 3.1. Mussel species collected in the NRGNR, June 1984 through September 1985.

<u>Actinonaias</u> <u>carinata</u> (Barnes, 1823)

<u>Cyclonaias</u> <u>tuberculata</u> (Rafinesgue, 1820)

<u>Elliptio</u> <u>dilatata</u> (Rafinesque, 1820)

<u>Tritoqonia</u> <u>verrucosa</u> (Rafinesque, 1820)

<u>Lampsilis</u> <u>fasciola</u> (Rafinesque, 1820)

<u>Lampsilis</u> <u>ovata</u> (Say, 1817)

<u>Alasmidonta</u> <u>marginata</u> (Say, 1818)

<u>Lasmigona</u> <u>subviridis</u> (Conrad, 1835)*

* - Represented only by empty valves found at two locations.

Table 3.2. Substrate composition of selected mussel beds within the NRGNR (*** - dominant, ** - subdominant, * - minor).

Bed	Sand	Gravel	Cobble	Small Boulder	Large Boulder	Bedrock
1		**	***	**	*	
2a		***	*			
2b		***	**	*		
2c	***	**	***	**		
3		***	***	**	**	
4		***	***	**		*
5		***	***	**	*	
6	**	***	***	**		
7		**	**	***		
8	***	***	*	*		
9		**	***	***	*	
10		***	***	**	*	
11	**	**	**	***		

Table 3.3. Minimum, maximum, and mean current velocities in selected mussel beds in the NRGNR.

	Current Velocity (m/s)		
Bed	Min.	Max.	Mean
1	0.02	0.17	0.10
2a	0.15	0.69	0.49
2b	0.02	0.22	0.10
2c	<0.01	0.08	0.04
3	0.46	0.76	0.56
4	0.15	0.41	0.29
5	<0.01	0.10	0.03
6	0.05	0.26	0.12
7	0.06	0.19	0.12
8	0.11	0.34	0.18
9	0.05	0.23	0.12
10	0.06	0.28	0.17
11	<0.01	0.11	0.07

Table 3.4. Aquatic vegetation (% surface area cover) in selected mussel beds in the NRGNR. * - present in trace quantities (<1%)

	Aquatic Vegetation (% cover)				
Bed	*Elodea* sp.	*Pomatogeton* spp.	*Heteranthera* sp.	*Valisineria* spp.	Total
1	-	-	-	-	0
2a	-	*	*	-	*
2b	-	-	-	*	*
2c	10	-	-	-	10
3	-	-	12	-	12
4	*	*	11	-	11
5	*	2	3	-	5
6	*	10	7	-	17
7	*	2	5	-	7
8	*	*	11	17	28
9	-	-	-	-	0
10	-	-	-	-	0
11	-	-	-	-	0

Table 3.5. Mussel densities (No./m^2) in river transects sampled by both snorkeling and quadrats to estimate densities.

		Method	
Mussel Bed	Transect	Snorkeling	Quadrats
MB 1	1	3.22	7.14
	2	3.24	3.00
	3	3.85	5.71
MB 5	4	2.42	4.00
	5	6.66	4.00
	6	6.70	2.00
	7	12.78	20.80
MB 6	8	1.88	2.67
	9	4.86	4.00
	10	6.20	6.50
	11	10.02	9.60
	12	16.02	25.00
	x	6.49	7.81

Table 3.6. Mussel densities (No./m^2) in selected mussel beds in the NRGNR.
* - indicates presence of empty valves.

Species	Mussel Bed 1	2a	2b	2c	3	4	5	6	7	8	9	10	11
Actinonaias carinata	3.12*	3.15*	7.14*	3.59*	4.71*	3.59*	6.28*	6.89*	3.16*	10.14*	13.56*	6.71*	2.25*
Cyclonaias tuberculata	0.04	0.10	0.14	0.06*	0.26*	0.03*	0.41*	0.59*	0.51*	0.36*	0.11*	0.20*	0.16*
Elliptio dilatata	0.38*	0.04	0.14*	0.04*	0.17*	0.07*	0.09*	0.10*	0.03*	<0.01*	0.06*	0.03*	0.06*
Tritogonia verrucosa	0.06*	0.27*	0.05*	-	0.27*	0.04*	-*	0.01*	-*	-*	-*	-*	-*
Lampsilis fasciola	-	-	0.04	-*	-	0.01*	0.01*	-	<0.01*	-*	-*	0.01*	0.01*
Lampsilis ovata	<0.01	-*	0.04*	-*	<0.01	<0.01*	0.01*	<0.01*	-*	-*	-*	<0.01*	-*
Alasmidonta marginata	-	-	0.09*	0.01	-	<0.01	-	-	-	<0.01	-	-	-
Total	3.61	3.56	7.64	3.70	5.41	3.74	6.79	7.60	3.70	10.51	13.74	6.95	2.48
Area Sampled (m^2)	335	52	56	109	300	350	350	300	241	300	300	300	300