07/15/2003

Viability Assessment Report
For
Lake Cumberland/Cave Run Lake Habitat Association

Prepared by
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I. Description of the Habitat Association

Lake Cumberland is a large man-made reservoir that has 1,255 miles of shoreline and a surface area of 50,250 acres. The lake contains 6,089,000 acre-feet of water with an average depth of 90 feet. Lake Cumberland drains an area of 5,789 square miles. The detailed portions of this report that pertain to Lake Cumberland, consider only the headwaters section falling within the Daniel Boone National Forest (DBNF). This constitutes approximately 75 miles of shoreline and a surface area of 1770 acres (USDA Forest Service, 1996).

Cave Run Lake is a relatively wide, moderately deep, man-made reservoir. The lake has 166 miles of shoreline and a surface area of 8,270 acres. It contains 222,600 acre-feet of water and an average depth of 15 feet with a maximum depth of about 65 feet (Axon, 1981). The lake is almost completely surrounded by DBNF ownership.

Location

Lake Cumberland is located about 10 miles southwest of Jamestown, Kentucky and 460.9 river miles from its confluence with the Ohio River. The bulk of the lake is located to the west of the DBNF in Wayne, Russell, and Clinton counties. A small portion of Lake Cumberland is located in the southwestern portion of the DBNF in Pulaski, McCreary and Laurel counties.

Cave Run Lake is on the Licking River 173.6 miles above its confluence with the Ohio River. The lake is located in the northern portion of, and is nearly surrounded by, the DBNF and is completely within Bath, Menifee, Morgan and Rowan counties.

Geology

Lake Cumberland lies within two ecological subsections, Southwestern Escarpment (221 Hc) and Eastern Karst Plain (222Eb)

The broad ridges of the Southwestern Escarpment are capped in a mixture of soft clay shale, siltstone and coal with underlying, resistant sandstone that forms cliffs when exposed. Narrow ridges are often capped in sandstone. The valley floors are clay shale and siltstones, or, in some cases, limestone. The ridges are Pennsylvanian-Age Lower Breathitt formation, and the valleys are of the Lower Breathitt and Lee formations.

The Eastern Karst Plain consists of a relatively low, rolling plain that is interrupted by moderate-elevation domes and a few knobs. The surface plain also is punctuated with small to large sinkholes that indicate underlying cave systems. The highest elevations are capped in soft clay shale, siltstone, coal and sandstones. Many lower knobs are capped with moderately resistant limestone. The valley floors are soft, easily eroded limestones and dolomites. The dominant geology of the valleys and side slopes is Mississippian-Age formations and the ridges Pennsylvanian-Age material (USDA Forest Service, 2001).

Cave Run Lake also falls within two ecological subsections, Northern Escarpment (221 Hb) and Low Hills Belt (221 He).

The Northern Escarpment is characterized by narrow to broad winding ridges with side slopes averaging 50 percent, but may exceed 65 percent in the most entrenched valleys. Ridges are capped with resistant conglomerate and sandstone, although mixtures of soft clay shale, siltstone, sandstone and coal are also present. The floors of the largest valleys consist of cherty limestone, sandstone, shale and siltstone. The geology includes Pennsylvanian-age Lower Breathitt and Lee formations on the ridges and side slopes, and Mississippian-Age Borden and Newman formations lower in the larger valleys.

Ridges that are broad and rolling with some narrow and winding, characterize the Low Hills Belt subsection. Side slopes average 30 to 40 percent but may exceed 50 percent in the most entrenched valleys. Rolling ridges are capped with a mixture of soft clay shale, siltstone, coal and a few ridges have small caps of resistant conglomerate. The geology includes Pennsylvania-Age Lower Breathitt and Lee formations (USDA Forest Service, 2001).

Hydrology

Lake Cumberland is located in the Cumberland River drainage system; two segments of this system are within the DBNF. The Upper Cumberland River drainage segment is located above Cumberland Falls and drains the Cumberland Mountains to the southeast and the Pine Mountain Overthrust to the northwest. The creeks, streams and rivers draining this area have extremely high gradients and few pools but numerous riffles, waterfalls and large sandstone substrates. Extensive reaches of the Cumberland River mainstream and its larger tributaries flow over bedrock and contain long boulder- and cobble-strewn shoals and deep rocky pools (USDA Forest Service, 2001).

The Middle Cumberland River Drainage segment of the Cumberland River system is upland in nature, with alternating riffles and pools, incised meanders, narrow floodplains, and rocky substrates. Streams and rivers bordering or heading on the sandstone-capped Southwestern Escarpment and Cumberland Plateau have high gradients with low waterfalls, boulder-strewn swift shoals, and deep holes. Creeks and streams draining the Cumberland Plateau immediately below Cumberland Falls also are high gradient and several have falls near their mouths (USDA Forest Service, 2001).

Cave Run Lake is located in the Licking River drainage system. The creeks, streams and rivers in this basin are generally upland, having moderate- to high-gradients, well-developed riffles and shoals, rocky substrates and poor to moderate floodplain development (USDA Forest Service, 2001).

Energy Source

An aquatic system's energy base is a combination of allochthonous (organic litter) and autochthonous (phytoplankton) material. In all standing water on the DBNF, all energy ultimately comes from light. In these aquatic communities there is a complex system by which energy is produced and consumed. This is not limited to the direct input of light, but also includes wind, rain and the cycling of minerals and compounds. These are open systems in the sense that there is input from the surrounding areas in the forms of detritus, organic material, minerals and compounds.

Dominant Vegetation

Lake Cumberland and Cave Run Lake are within the mixed mesophytic forest region of the eastern deciduous forest biome. This is represented by a complex mixture of vegetation resulting from variations in soil and aspect and changes from historic use patterns.

Aquatic vegetation is limited due to seasonal fluctuations in lake levels, lakeshore steepness and the impact of wave action caused by recreational watercraft.

II. Current Status of the Habitat Association on the Daniel Boone National Forest

The landscape of the area that is now the DBNF has changed dramatically since the 1800's when the dominant use was small-scale subsistence farming. Logging and land clearing for agriculture accelerated in the early 1900's, and by 1930 most of eastern Kentucky had been cleared. Faced with economic necessity, many people either abandoned or sold their land to the Federal Government in the 1920's and 1930's under the Weeks Act. From the 1920's to the 1970's mining companies stripped and deep mined coal on adjacent private lands (USDA Forest Service, 2001). Congress authorized land acquisition for the DBNF, first known as the Cumberland National Forest, in 1937. Historically, natural bodies of standing water were rare in what is now the DBNF.

Construction of Wolf Creek Dam, that forms Lake Cumberland, began in August of 1941 and was completed in 1950. The purposes for building the lake were flood control and hydroelectric power (U. S. Army Corps of Engineers, 1981). The dam controls the drainage of 5,789 square miles much of this is on the DBNF.

Construction on the Cave Run Lake project began in 1965 and was completed in 1973. The primary function of the lake was to provide flood protection to the lower Licking River. The lake controls surface runoff from an 826 square mile watershed (U. S. Army Corps of Engineers, 1981).

III. Management Needs: Recommendations for the Conservation of Habitat to Ensure Species Viability

Although Lake Cumberland and Cave Run Lake are man-made reservoirs, they provide habitat for several species for which continued expectation of existence on the forest or are needed to ensure continued existence on the forest of other at risk species. Due to fluctuating water levels, several species occur in very limited populations. Other species that could occur here do not due to this habitat restriction. The fluctuations in the water level are controlled by another agency and are out of the control of the DBNF. Habitat management includes protection and improvement to ensure species viability. Protection involves preventing actions or alterations, to the habitat, that adversely affect species viability.

The desired goal would be to maintain or exceed State water quality standards for beneficial downstream uses and aquatic biodiversity; maintain and restore water quality necessary to support healthy aquatic ecosystems and to ensure survival, growth, reproduction, and migration of aquatic dependent species; maintain and/or restore the biological, physical, and chemical integrity of aquatic ecosystems (USDA Forest Service, 2001).

The desired future condition of this habitat association is to maintain a generally undisturbed area around the lakes and maintain or increase their water quality and productivity to ensure a high likelihood that species within this association will persist or increase on the forest over the planning period.

Forest-Wide Standards

- Follow direction in FSM 2630 (Management of Wildlife and Fish Habitat) and FSM 2670 (Threatened, Endangered, and Sensitive Plants and Animals).
    - *Rationale: These provide guidance for management decisions specific to wildlife, fish, and PETS species.*
- Follow guidelines in FSH 2609.13 (Wildlife and Fisheries Program Management Handbook).
    - *Rationale: These provide guidance for management decisions specific to wildlife and fisheries.*
- Meet or exceed all Federal, State, and local water quality standards for beneficial downstream uses and aquatic biodiversity.
    - *Rationale: The National Forest Management Act of 1976 requires the Forest Service to maintain or enhance water quality, which in turn helps maintain healthy aquatic ecosystems.*
- Designate areas along shorelines (300’ zone) closed to camping, except at designated sites.

  - *Rationale: To provide for resource protection and prevent disruption of habitat critical to species at risk of loosing viability. Many of the species that use this habitat association are found along the edge or transition areas between water and forest.*

- National Forest vegetation management will not be proposed in the area adjacent to Lake Cumberland and Cave Run Lake unless the management will have beneficial or no adverse effect on species that use this association.

  - *Rationale: Mature forests with nesting, roosting, perching, and cavity trees are habitat modifiers required by one or more of the following, bald eagle, wood duck, and hooded merganser.*

- Established and/or suspected bald eagle nesting sites will be managed following the "Habitat Management Guidelines for the Bald Eagle in the Southeast Region"

  - *Rationale: Protecting bald eagle nesting sites may increase species viability.*

- Manage special dispersed recreation activities, fishing tournaments. Schedule and regulate use of facilities, time of year, number of users, and designate use areas.

  - *Rationale: Limit adverse impact on species that use Lake Cumberland and Cave Run Lake as habitat.*

- Supplement habitat with naturally and artificially created nesting structures if available nesting and roosting sites are a limiting factor. Provide wood duck nest boxes and create snags in appropriate habitat.

  - *Rationale: Species viability may be increased if these are limiting factors in the area.*

- Provide fish attractors in areas with limited cover.

  - *Rationale: Increase lake productivity for species dependent of on fish as a food source, such as the bald eagle, wood duck, and hooded merganser.*

- Comply with water goals as specified in the Clean Water Act and other Congressional mandates.

  - *Rationale: The Clean Water Act mandates the maintenance of biological integrity; this would help to enhance and maintain habitat viability.*

- Determine if the applicable water quality standards are being met.

  - *Rationale: This will help insure maintenance or improvement of the habitat association and the viability of the species that inhabit it.*

IV. Management Needs: Monitoring and Inventory to Ensure Species Viability

Although there are no known aquatic species in Lake Cumberland or Cave Run Lake which are at risk of loosing population viability the lakes are used by several nonaquatic species that are at risk (see appendix A).

- Habitat persistence and health should be regularly monitored while periodic monitoring should be conducted to insure individual species viability. This could be accomplished in cooperation with KDFWR and other state and federal agencies. (Moderate priority)

- If the current status of a species is not known, then inventory of species that are potentially at risk of loosing population viability should be carried out. The general strategy is to document existing habitat and/or species condition and status, and then assess for degradation or potential improvement. (High priority)

- A Water Resource Inventory will be conducted. The amounts and kinds of data collected will be consistent with identified management issues and concerns, and in accordance with approved Forest Plan. (Moderate priority)

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Attachment A.

Species List: Lake Cumberland/Cave Run Lake Habitat Association

Class	Common Name/ Species
AMPHIBIAN	Mudpuppy/ *Necturus maculosus*
BIRD	Wood Duck/ *Aix sponsa*
	Bald Eagle/ *Haliaeetus leucocephalus*
	Hooded Merganser/ *Lophodytes cucullatus*
	Pied-billed Grebe *Podilymbus podiceps*
FISH	Rock Bass/ *Ambloplites rupestris*
	Freshwater Drum/ *Aplodinotus grunniens* (Lake Cumberland)
	Muskellunge (Native pop. only)/ *Esox masquinongy* (Cave Run Lake)
	Northern Hogsucker/ *Hypentelium nigricans*
	Bluegill/ *Lepomis macrochirus*
	Smallmouth Bass/ *Micropterus dolomieui*
	Largemouth Bass/ *Micropterus salmoides*
	Yellow Perch/ *Perca flavescens*
	White Crappie/ *Pomoxis annularis*
	Walleye (Native pop. only)/ *Stizostedion vitreum* (Lake Cumberland)
PLANTS	Sweet waterlily/ *Nymphaea odorata*
	Eelgrass/ *Vallisneria Americana*
	Spotted Pondweed/ *Potamogeton pulcher*
	Engelmann's quillwort/ *Isoetes engelmannii*
	Sphagnum moss/ *Sphagnum macrophyllum*

Attachment B.

Lake Cumberland/Cave Run Lake Habitat Association Species/Habitat Relationships with References

AMPHIBIAN

Mudpuppy – *Necturus maculosus* – The mudpuppy is entirely aquatic, inhabiting lakes, pond, rivers, streams, and other permanent bodies of water. They prefer either weedchoked waters or those with abundant shelter in the form of debris, rocks, mud, and/or leaf beds. They require unpolluted, clean water (Wilson, 1995)

BIRD

Wood Duck – *Aix sponsa* – These birds live around a variety of aquatic habitats that have cavities available for nesting. Swamps, wooded streams, lakes, ponds, reservoirs, and marshes provide suitable habitat. Nesting is in live or dead trees, within cavities, hollow limbs, and even abandoned pileated woodpecker holes. Trees utilized are usually near or above water—often in sycamore and maples (Mengel 1965). Artificial nest boxes are widely used. Birds forage in shallow water for aquatic plants, insects, and small fish. In the winter, wood ducks often eat acorns. The wood duck would be likely to be found utilizing the forest immediately adjacent to rivers, larger streams, lakes, and permanent ponds for nesting.

Bald Eagle – *Haliaeetus leucocephalus* – This federally listed species is dependent on aquatic habitat, primarily river floodplains, lakes, and natural and human-built reservoirs. It utilizes both standing and flowing fresh water sources (and salt water, in coastal areas) that have large trees suitable for nesting, perching and roosting. Suitable trees are at least 20" dbh in size and usually growing near the water (Hamel, 1992). In Kentucky, the birds have nested and wintered around wetland/floodplain habitats and reservoirs resulting from the impoundment of rivers (e.g., Laurel River Lake on the DBNF). Wintering birds are known to occur on major impoundments on the DBNF. Records of attempted nesting exist for Laurel River Lake although no active nests are currently known to exist. The bald eagle would be attracted to the forest along large rivers for nesting and wintering.

Hooded Merganser – *Lophodytes cucullatus* – This species of waterfowl requires wooded areas with clear water streams, rivers, swamps, ponds, and lakes with cavity trees present (DeGraaf et. al., 1991). Usually forages in freshwater situations such as swamps, ponds or lakes (Hamel, 1992). This species is seldom found far from floodplain situations and usually requires a good stand of fairly mature forest nearby for nest sites (Palmer-Ball, 1996). They require cavities for nesting and may utilize artificial cavities originally constructed for wood ducks (Bellrose, 1980). The hooded merganser would be particularly attracted to the backwater areas of rivers and larger streams, where it can occasionally be found foraging and nesting.

Pied-billed Grebe – *Podilymbus podiceps* – The destruction of wetland habitat has led to a decrease in numbers of this species. Marshes, water impoundments, and shallow edges of lakes and ponds provide habitat for these birds. Marshy, shallow water with abundant emergent vegetation in which to nest is required during the breeding season. During winter, the birds use similar habitat, but with an increased use of open water. On 13 June 2000, an MSU grad student observed a pied-billed grebe and four young on an USFS-built wetland near Beaver Creek, on the Morehead R.D. (Biebighauser 2001).

FISH

Rock Bass – *Ambloplites rupestri* – This species can be found associated with sheltered pool areas in cold to warm creeks and rivers. They are occasionally associated with rocky shores in reservoirs. They are usually found in the cover of roots and brush (Etnier and Starnes 1993). Burr and Warren (1986) reports the rock bass in pools from clear upland streams and rivers with boulder, cobble, pebble, and gravel substrate, and associated with emergent vegetation or instream shelter.

Freshwater Drum – *Aplodinotus grunniens* (Lake Cumberland) – The Freshwater Drum can be a common inhabitant of the backwaters and areas of sluggish current in large rivers and reservoirs. They are very tolerant of turbidity (Etnier and Starnes 1993) but appear to prefer clear waters and clean bottoms (Trautman 1981). Substrate preferences appear to be gravel, sand, mud, and organic debris (Burr and Warren 1986).

Muskellunge (Native Pop. only) – *Esox masquinongy* (Cave Run Lake) – These fish inhabit relatively clear upland rivers where they occur in large rocky pools. They appear to prefer areas about 1 m. deep with plenty of fallen trees. Spawning habitat is believed to be shallow waters near the ends of pools areas. Movement during spawning is upstream and into smaller tributaries (Etnier and Starnes 1993). They are found over cobble, pebble, gravel, and sand substrate and in association with standing submerged timber, fallen logs with accumulated debris, or aquatic vegetation (Burr and Warren 1986).

Northern Hogsucker – *Hypentelium nigricans* – The northern hogsucker prefers warmwater, and riffles or adjacent areas, of moderate sized creeks and small rivers. It can be found in coldwater streams, tiny creeks, large rivers, and occasionally in reservoirs. It requires shallow gravel areas for spawning (Etnier and Starnes 1993). Preferred substrates include bedrock, cobble, pebble, gravel, and sand (Burr and Warren 1986).

Bluegill – *Lepomis macrochirus* – This species can be found in nearly all sizes of standing and moving water. It is most abundant in lakes and ponds and prefers shallow water with the cover of vegetation, woody debris, and/or rocks (Etnier and Starnes 1993). It typically occurs in clear, quiet waters where the bottom is of mixed cobble, pebble, gravel, sand, mud, and organic debris (Burr and Warren 1986).

Smallmouth Bass – *Micropterus dolomieui* – The smallmouth bass can be found in clear upland creeks, rivers, lakes and reservoirs. It prefers areas with submerged logs, stumps and rock outcrops and some current if in a stream. In reservoirs, steep rocky slopes along submerged river and creek channels are preferred (Etnier and Starnes 1993). In lotic waters it is generally associated with clean pools with substrates of boulder, cobble, pebble, and gravel (Burr and Warren 1986).

Largemouth Bass – *Micropterus salmoides* – The largemouth bass inhabits sluggish waters in large streams, lakes and reservoirs. This species is more tolerant of turbidity than other members of the genus (Etnier and Starnes 1993). It is often found in association with vegetated littoral areas, standing timber, stumps and other cover. It can be found over substrates containing cobble, pebble, gravel, sand, mud, and organic debris (Burr and Warren 1986).

Yellow Perch – *Perca flavescens* – The yellow perch inhabits streams and lakes and prefers quiet waters often associated with rooted aquatic vegetation (Etnier and Starnes 1993). They are found in greatest numbers in clear waters with a substrate of muck, organic debris, sand or gravel and an abundance of rooted aquatic vegetation (Trautman 1981).

White Crappie – *Pomoxis annularis* – The white crappie inhabits sluggish streams and lakes and is quite tolerant of turbidity. It prefers areas with plenty of cover such as brush and other obstructions. Nests are constructed near the cover of brush or overhanging banks in shallow protected areas such as coves or deeper overflow pools (Etnier and Starnes 1993). The white crappie is also found in large ponds and impoundments, over hard and soft bottoms, and areas containing aquatic vegetation, submerged brush, logs, stumps, and tree roots (Trautman 1981). It can also be found in rivers and large rivers over substrates of gravel, sand, mud, and organic debris often in association with emergent and aquatic bed vegetation, scrub-shrub, forested, and instream shelter (Burr and Warren 1986).

Walleye (Native pop. only) – *Stizostedion vitreum* (Lake Cumberland) – Walleye can be found in larger rivers and clearer reservoirs. Most spawning occurs in rivers, when accessible, but also occurs in tailwaters, reefs or firm shorelines of lakes, and in flooded marshes. Spawning substrate varies from boulder and sand to flooded vegetation (Etnier and Starnes 1993). It can also be found in streams and rivers in the deep open waters of pools with abundant bottom cover. Substrate may also include cobble, pebble, gravel, and sand (Burr and Warren 1986).

PLANTS

Sweet waterlily – *Nymphaea odorata* – is a true aquatic species known from the northern US to the Gulf Coast. Submerged roots are a requirement. At least part of the submergence requirement is for protection against freezing in winter. Relatively still water is also required. This can be a protected pool in a stream or lake or on a small pond. It is known from many sites in Kentucky but only one recently discovered site on the DBNF. It is probable that waterfowl introduced the plant to these created wetlands.

Eelgrass – *Vallisneria Americana* – is a true aquatic species, for which submerged roots are a requirement. Relatively still water is also required, as the leaves are thin and fragile. The plants are occasionally found in streams in areas of sluggish current, but are also found in ponds, including stripmine ponds, and lakes. Relatively high quality water is required by the species.

Spotted Pondweed – *Potamogeton pulcher* – is a coastal plain species with scattered interior stations. It is found in shallow, quiet water and muddy shores. The DBNF records are from ponds and slow stream margins.

Engelmann's quillwort – *Isoetes engelmannii* – is a semi-aquatic species. The plants can survive entirely submerged, or for several months out of water if the soil remains moist. At the time spores are released, the leaf bases must be submerged for sexual reproduction to be successful. The plants are generally in shallow water (under 2 feet deep) and are found in both permanent and seasonal water including ruts, roadside ditches, ponds, lake margins, and occasionally in streamhead wetlands and streams.

Sphagnum moss – *Sphagnum macrophyllum* – is a coastal plain species ranging from Newfoundland to Florida then west to Texas. In is known from the Cumberland Plateau in Tennessee and Kentucky. The Kentucky site is on the Morehead District of the DBNF. Throughout its range it is found in shallow, quiet water in lakes, ponds, roadside ditches, and southward in gum-cypress swamps. On the DBNF, it is known from one small pond near Cave Run Lake, where it covers much of the surface.

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Attachment C.

Lake Cumberland/Cave Run Lake Habitat Association Matrix

Habitat	Temp.	Hab. Modifers	Habitat Modifers2	Class	Species	Common_Name
General Standing Water	Warm	Glide	submerged roots	P-DIC	Nymphaea odorata	Southern Fragrant Waterlily
General Standing Water	Warm	Pool	pools/backwaters	P-MON	Potamogeton pulcher	Spotted Pondweed
General Standing Water	Warm	Pool	shallow water	P-FER	Isoetes engelmannii	Engelman's Quillwort
General Standing Water	Warm	Pool	shallow water	P-MOS	Sphagnum macrophyllum	Large-leaved sphagnum
General Standing Water	Warm	Pool	submerged roots	P-DIC	Nymphaea odorata	Southern Fragrant Waterlily
General Standing Water	Warm	Pool	submerged roots	P-MON	Vallisneria americana	Eelgrass
Lentic	Cold	Pool		FISH	Hypentelium nigricans	Northern Hogsucker
Lentic	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Ambloplites rupestris	Rock Bass
Lentic	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Lepomis macrochirus	Bluegill
Lentic	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Micropterus dolomieui	Smallmouth Bass
Lentic	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Micropterus salmoides	Largemouth Bass
Lentic	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Pomoxis annularis	White Crappie
Lentic	Warm	Pool	natural aquatic vegetation	FISH	Perca flavescens	Yellow Perch
Lentic	Warm	Pool	pools/backwaters	FISH	Perca flavescens	Yellow Perch
Lentic	Warm	Pool	skip	FISH	Aplodinotus grunniens	Freshwater Drum
				BIRD	Lophodyets cucullatus	Hooded Merganser
				BIRD	Podilymbus podiceps	Pied-billed Grebe
				BIRD	Aix sponsa	Wood Duck
				BIRD	Haliaeetus leucocephalus	Bald Eagle
				FISH	Esox masquiningy	Muskellunge
				FISH	Stezostedion vitreum	Walleye
				AMPHIB	Necturus maculosus	Mudpuppy

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I. Description of the Habitat Association

Laurel River Lake is a relatively narrow, deep, man-made reservoir. At maximum pool level, 1018.5 feet elevation, the lake has a surface area of 6,060 acres, contains 435,600 acre-feet of water, and includes 206 miles of shoreline. The average depth is 72 feet and the maximum depth is 249 feet. The maximum width of the reservoir is approximately one-half mile but it is much narrower over most of its length. The lake drains 282 square miles (U. S. Army Corps of Engineers, 1981).

- **Location**

  The Laurel River Lake is located in the southern portion of the Daniel Boone National Forest (DBNF). It forms a boundary between Laurel and Whitley counties and is surrounded completely by these counties. The lake is located on the Laurel River with the dam located 2.3 miles above its confluence with the Cumberland River.

- **Geology**

  The underlying geology of an area directly influences water chemistry, basin shape and structure, and lake substrate. The prevalent geologic structures at Laurel River Lake are within two ecological subsections, Southwestern Escarpment (221 Hc) and a small part of Low Hills Belt (221 He).

  The broad ridges of the Southwestern Escarpment are capped in a mixture of soft clay shales, siltstone and coal with underlying, resistant sandstone that forms cliffs when exposed. Narrow ridges are often capped in sandstone. The valley floors are clay shales and siltstones, or, in some cases, limestone. The ridges are Pennsylvanian-Age Lower Breathitt formation, and the valleys are of the Lower Breathitt and Lee formations.

  The Low Hills Belt makes up a small part of the geology of the Laurel Lake area. It is characterized by ridges that are broad and rolling with some narrow and winding. Side slopes average 30 to 40 percent but may exceed 50 percent in the most entrenched valleys. Rolling ridges are capped with a mixture of soft clay shales, siltstone, and coal, and a few ridges have small caps of resistant conglomerate. The geology includes Pennsylvania-Age Lower Breathitt and Lee formations (USDA Forest Service, 2001).

- **Hydrology**

Precipitation in the area occurs throughout the year with seasonal variation. Laurel River Lake and Laurel River are part of the Middle Cumberland River Drainage segment of the Cumberland River system. Streams and rivers in this segment are upland in nature, with alternating riffles and pools, incised meanders, narrow floodplains, and rocky substrates. Streams and rivers bordering or heading on the sandstone-capped Southwestern Escarpment and Cumberland Plateau have high gradients with low waterfalls, boulder-strewn swift shoals, and deep holes (USDA Forest Service, 2001).

Laurel River Lake is eutrophic (fertile) in the Laurel River headwaters and becomes progressively oligotrophic (less fertile) downlake. The majority of the lake is oligotrophic. As a result of this oligotrophic condition the thermocline, which develops in the warmer months, maintains sufficient oxygen to provide habitat for coolwater species (Williams, 1997).

- **Energy**

An aquatic systems energy base is a combination of allochthonous (organic litter) and autochthonous (phytoplankton) material. In all standing water on the DBNF, all energy ultimately comes from light. In these aquatic communities there is a complex system by which energy is produced and consumed. This is not limited to the direct input of light, but also includes wind, rain and the cycling of minerals and compounds. These are open systems in the sense that there is input from the surrounding areas in the forms of detritus, organic material, minerals and compounds.

- **Dominant Vegetation**

Laurel River Lake is within the mixed mesophytic forest region of the eastern deciduous forest biome. This is represented by a complex mixture of vegetation resulting from variations in soil and aspect and changes from historic use patterns.

Aquatic vegetation is very limited due to seasonal fluctuations in lake level, lakeshore steepness and the impact of wave action caused by recreational watercraft.

II. Current Status of the Habitat Association on the Daniel Boone National Forest

The initial occupation of the area by white settlers occurred in the years following 1775, with the opening of the “Wilderness Road” and Cumberland Gap, located about 40 miles southeast of Laurel River Lake. It wasn’t until the late 19th and early 20th century, when railroad service was extended into this area to extract the timber and mineral resources, that there was a substantial increase in population. Growth in the area immediately surrounding Laurel River Lake was less stimulated than the rest of the Cumberland Plateau, largely due to the rugged terrain. Congress authorized land acquisition for the DBNF, first known as the Cumberland National Forest, in 1937.

Initial construction of the dam began in December 1963, with clearing for the impoundment starting in the fall of 1972. The dam was completed and filling of the impoundment began in

September of 1973. The lake reached maximum power pool, 1018.5 feet elevation above mean sea level, in the fall of 1974. The reservoir was constructed for hydroelectric power generation and general recreation.

III. Management Needs: Recommendations for the Conservation of Habitat to Ensure Species Viability

Although Laurel River Lake is a man-made reservoir, it provides habitat for several species for which continued expectation of existence on the forest or are needed to ensure continued existence on the forest of other at risk species. Due to fluctuating water levels, several species occur in very limited populations. Other species that could occur here do not due to this habitat restriction. The fluctuations in the water level are out of the control of the DBNF. Habitat management includes protection and improvement to ensure species viability. Protection involves preventing actions or alterations, to the habitat, that adversely affect species viability.

The desired goal would be to maintain or exceed State water quality standards for beneficial downstream uses and aquatic biodiversity; maintain and restore water quality necessary to support healthy aquatic ecosystems and to ensure survival, growth, reproduction, and migration of aquatic dependent species; maintain and/or restore the biological, physical, and chemical integrity of aquatic ecosystems (USDA Forest Service, 2001).

The desired future condition of this habitat association is to maintain a generally undisturbed area around the lake and maintain or increase its water quality and productivity to ensure a high likelihood that species within this association will persist or increase on the forest over the planning period.

Forest-Wide Standards

- Follow direction in FSM 2630 (Management of Wildlife and Fish Habitat) and FSM 2670 (Threatened, Endangered, and Sensitive Plants and Animals).
    - *Rationale: These provide guidance for management decisions specific to wildlife, fish, and PETS species.*
- Follow guidelines in FSH 2609.13 (Wildlife and Fisheries Program Management Handbook).
    - *Rationale: These provide guidance for management decisions specific to wildlife and fisheries.*
- Meet or exceed all Federal, State, and local water quality standards for beneficial downstream uses and aquatic biodiversity.
    - *Rationale: The National Forest Management Act of 1976 requires the Forest Service to maintain or enhance water quality, which in turn helps maintain healthy aquatic ecosystems.*

- Designate areas along shorelines (300’ zone) closed to camping.
  - o *Rationale: To provide for resource protection and prevent disruption of habitat critical to species at risk of loosing viability. Many of the species that use this habitat association are found along the edge or transition areas between water and forest.*
- National Forest vegetation management will not be proposed in the area adjacent to Laurel River Lake unless the management will be beneficial to or have no adverse effect on species that use this association.
  - o *Rationale: Mature forests with nesting, roosting, perching, and cavity trees are habitat modifiers required by one or more of the following, bald eagle, wood duck, and hooded merganser.*
- Established and/or suspected bald eagle nesting sites will be managed following the “Habitat Management Guidelines for the Bald Eagle in the Southeast Region”
  - o *Rationale: Protecting bald eagle nesting sites may increase species viability.*
- Manage special dispersed recreation activities, fishing tournaments. Schedule and regulate use of facilities, time of year, number of users, and designate use areas.
  - o *Rationale: Limit adverse impact on species that use Laurel Lake as habitat.*
- Supplement habitat with naturally and artificially created nesting structures if available nesting and roosting sites are a limiting factor. Provide wood duck nest boxes and create snags in appropriate habitat.
  - o *Rationale: Species viability may be increased if these are limiting factors in the area.*
- Provide fish attractors in areas with limited cover.
  - o *Rationale: Increase lake productivity for species dependent of on fish as a food source, such as the bald eagle, wood duck, and hooded merganser.*
- Comply with water goals as specified in the Clean Water Act and other Congressional mandates.
  - o *Rationale: The Clean Water Act mandates the maintenance of biological integrity; this would help to enhance and maintain habitat viability.*
- Determine if the applicable water quality standards are being met.
  - o *Rationale: This will help insure maintenance or improvement of the habitat association and the viability of the species that inhabit it.*

IV. Management Needs: Monitoring and Inventory to Ensure Species Viability

Although there are no known aquatic species in Laurel Lake which are at risk of loosing population viability the lake is used by several nonaquatic species that are at risk (see appendix A).

- Habitat persistence and health should be regularly monitored while periodic monitoring should be conducted to insure individual species viability. This could be accomplished in cooperation with KDFWR and other state and federal agencies. (Moderate priority)
- If the current status of a species is not known, then inventory of species that are potentially at risk of loosing population viability should be carried out. The general strategy is to document existing habitat and/or species condition and status, and then assess for degradation or potential improvement. (High priority)
- A Water Resource Inventory will be conducted. The amounts and kinds of data collected will be consistent with identified management issues and concerns, and in accordance with approved Forest Plan. (Moderate priority)

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Attachment A.

Species List: Laurel River Lake Habitat Association

CLASS	Common Name/ Species
AMPHIBIAN	Mudpuppy/ *Necturus maculosus*
BIRD	Wood Duck/ *Aix sponsa*
	Bald Eagle/ *Haliaeetus leucocephalus*
	Hooded Merganser/ *Lophodytes cucullatus*
	Pied-billed Grebe/ *Podilymbus podiceps*
FISH	Rock Bass/ *Ambloplites rupestris*
	Northern Hogsucker/ *Hypentelium nigricans*
	Bluegill/ *Lepomis macrochirus*
	Smallmouth Bass/ *Micropterus dolomieui*
	Largemouth Bass/ *Micropterus salmoides*
	Yellow Perch/ *Perca flavescens*
	White Crappie/ *Pomoxis annularis*
	Walleye (Native pop. only)/ *Stizostedion vitreum*
PLANTS	Engelmann's quillwort/ *Isoetes engelmannii*
	Sweet waterlily/ *Nymphaea odorata*
	Spotted Pondweed/ *Potamogeton pulcher*
	Sphagnum moss/ *Sphagnum macrophyllum*
	Eelgrass/ *Vallisneria Americana*

Attachment B

Laurel River Lake Species/Habitat Association

AMPHIBIAN

Mudpuppy – *Necturus maculosus* – The mudpuppy is entirely aquatic, inhabiting lakes, pond, rivers, streams, and other permanent bodies of water. They prefer either weedchoked waters or those with abundant shelter in the form of debris, rocks, mud, and/or leaf beds. They require unpolluted, clean water (Wilson, 1995)

BIRD

Wood Duck – *Aix sponsa* – These birds live around a variety of aquatic habitats that have cavities available for nesting. Swamps, wooded streams, lakes, ponds, reservoirs, and marshes provide suitable habitat. Nesting is in live or dead trees, within cavities, hollow limbs, and even abandoned pileated woodpecker holes. Trees utilized are usually near or above water—often in sycamore and maples (Mengel 1965). Artificial nest boxes are widely used. Birds forage in shallow water for aquatic plants, insects, and small fish. In the winter, wood ducks often eat acorns. The wood duck would be likely to be found utilizing the forest immediately adjacent to rivers, larger streams, lakes, and permanent ponds for nesting.

Bald Eagle – *Haliaeetus leucocephalus* – This federally listed species is dependent on aquatic habitat, primarily river floodplains, lakes, and natural and human-built reservoirs. It utilizes both standing and flowing fresh water sources (and salt water, in coastal areas) that have large trees suitable for nesting, perching and roosting. Suitable trees are at least 20” dbh in size and usually growing near the water (Hamel, 1992). In Kentucky, the birds have nested and wintered around wetland/floodplain habitats and reservoirs resulting from the impoundment of rivers (e.g., Laurel River Lake on the DBNF). Wintering birds are known to occur on major impoundments on the DBNF. Records of attempted nesting exist for Laurel River Lake although no active nests are currently known to exist. The bald eagle would be attracted to the forest along large rivers for nesting and wintering.

Hooded Merganser – *Lophodytes cucullatus* – This species of waterfowl requires wooded areas with clear water streams, rivers, swamps, ponds, and lakes with cavity trees present (DeGraaf et. al., 1991). Usually forages in freshwater situations such as swamps, ponds or lakes (Hamel, 1992). This species is seldom found far from floodplain situations and usually requires a good stand of fairly mature forest nearby for nest sites (Palmer-Ball, 1996). They require cavities for nesting and may utilize artificial cavities originally constructed for wood ducks (Bellrose, 1980). The hooded merganser would be particularly attracted to the backwater areas of rivers and larger streams, where it can occasionally be found foraging and nesting.

Pied-billed Grebe – *Podilymbus podiceps* – The destruction of wetland habitat has led to a decrease in numbers of this species. Marshes, water impoundments, and shallow edges of lakes and ponds provide habitat for these birds. Marshy, shallow water with abundant emergent vegetation in which to nest is required during the breeding season. During winter, the birds use similar habitat, but with an increased use of open water. On 13 June 2000, an MSU grad student observed a pied-billed grebe and four young on an USFS-built wetland near Beaver Creek, on the Morehead R.D. (Biebighauser 2001).

FISH

Rock Bass – *Ambloplites rupestris* – This species can be found associated with sheltered pool areas in cold to warm creeks and rivers. They are occasionally associated with rocky shores in reservoirs. They are usually found in the cover of roots and brush (Etnier and Starnes 1993). Burr and Warren (1986) reports the rock bass in pools from clear upland streams and rivers with boulder, cobble, pebble, and gravel substrate, and associated with emergent vegetation or instream shelter.

Northern Hogsucker – *Hypentelium nigricans* – The northern hogsucker prefers warmwater, and riffles or adjacent areas, of moderate sized creeks and small rivers. It can be found in coldwater streams, tiny creeks, large rivers, and occasionally in reservoirs. It requires shallow gravel areas for spawning (Etnier and Starnes 1993). Preferred substrates include bedrock, cobble, pebble, gravel, and sand (Burr and Warren 1986).

Bluegill – *Lepomis macrochirus* – This species can be found in nearly all sizes of standing and moving water. It is most abundant in lakes and ponds and prefers shallow water with the cover of vegetation, woody debris, and/or rocks (Etnier and Starnes 1993). It typically occurs in clear, quiet waters where the bottom is of mixed cobble, pebble, gravel, sand, mud, and organic debris (Burr and Warren 1986).

Smallmouth Bass – *Micropterus dolomieui* – The smallmouth bass can be found in clear upland creeks, rivers, lakes and reservoirs. It prefers areas with submerged logs, stumps and rock outcrops and some current if in a stream. In reservoirs, steep rocky slopes along submerged river and creek channels are preferred (Etnier and Starnes 1993). In lotic waters it is generally associated with clean pools with substrates of boulder, cobble, pebble, and gravel (Burr and Warren 1986).

Largemouth Bass – *Micropterus salmoides* – The largemouth bass inhabits sluggish waters in large streams, lakes and reservoirs. This species is more tolerant of turbidity than other members of the genus (Etnier and Starnes 1993). It is often found in association with vegetated littoral areas, standing timber, stumps and other cover. It can be found over substrates containing cobble, pebble, gravel, sand, mud, and organic debris (Burr and Warren 1986).

Yellow Perch – *Perca flavescens* – The yellow perch inhabits streams and lakes and prefers quiet waters often associated with rooted aquatic vegetation (Etnier and Starnes 1993). They are found in greatest numbers in clear waters with a substrate of muck, organic debris, sand or gravel and an abundance of rooted aquatic vegetation (Trautman 1981).

White Crappie – *Pomoxis annularis* – The white crappie inhabits sluggish streams and lakes and is quite tolerant of turbidity. It prefers areas with plenty of cover such as brush and other obstructions. Nests are constructed near the cover of brush or overhanging banks in shallow protected areas such as coves or deeper overflow pools (Etnier and Starnes 1993). The white crappie is also found in large ponds and impoundments, over hard and soft bottoms, and areas containing aquatic vegetation, submerged brush, logs, stumps, and tree roots (Trautman 1981). It can also be found in rivers and large rivers over substrates of gravel, sand, mud, and organic debris often in association with emergent and aquatic bed vegetation, scrub-shrub, forested, and instream shelter (Burr and Warren 1986).

Walleye (Native pop. only) – *Stizostedion vitreum* – Walleye can be found in larger rivers and clearer reservoirs. Most spawning occurs in rivers, when accessible, but also occurs in tailwaters, reefs or firm shorelines of lakes, and in flooded marshes. Spawning substrate varies from boulder and sand to flooded vegetation (Etnier and Starnes 1993). It can also be found in streams and rivers in the deep open waters of pools with abundant bottom cover. Substrate may also include cobble, pebble, gravel, and sand (Burr and Warren 1986).

PLANTS

Sweet waterlily – *Nymphaea odorata* – is a true aquatic species known from the northern US to the Gulf Coast. Submerged roots are a requirement. At least part of the submergence requirement is for protection against freezing in winter. Relatively still water is also required. This can be a protected pool in a stream or lake or on a small pond. It is known from many sites in Kentucky but only one recently discovered site on the DBNF. It is probable that waterfowl introduced the plant to these created wetlands.

Eelgrass – *Vallisneria Americana* – is a true aquatic species, for which submerged roots are a requirement. Relatively still water is also required, as the leaves are thin and fragile. The plants are occasionally found in streams in areas of sluggish current, but are also found in ponds, including stripmine ponds, and lakes. Relatively high quality water is required by the species.

Spotted Pondweed – *Potamogeton pulcher* – is a coastal plain species with scattered interior stations. It is found in shallow, quiet water and muddy shores. The DBNF records are from ponds and slow stream margins.

Engelmann’s quillwort – *Isoetes engelmannii* – is a semi-aquatic species. The plants can survive entirely submerged, or for several months out of water if the soil remains moist. At the time spores are released, the leaf bases must be submerged for sexual reproduction to be successful. The plants are generally in shallow water (under 2 feet deep) and are found in both permanent and seasonal water including ruts, roadside ditches, ponds, lake margins, and occasionally in streamhead wetlands and streams.

Sphagnum moss – *Sphagnum macrophyllum* - is a coastal plain species ranging from Newfoundland to Florida then west to Texas. In is known from the Cumberland Plateau in

Tennessee and Kentucky. The Kentucky site is on the Morehead District of the DBNF. Throughout its range it is found in shallow, quiet water in lakes, ponds, roadside ditches, and southward in gum-cypress swamps. On the DBNF, it is known from one small pond near Cave Run Lake, where it covers much of the surface.

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Attachment C.

Laurel River Lake Habitat Association Matrix

Habitat	Temp.	Hab. Modifers	Habitat Modifers2	Class	Species	Common Name
General Standing Water	Warm	Glide	submerged roots	P-DIC	Nymphaea odorata	Southern Fragrant Waterlily
General Standing Water	Warm	Pool	pools/backwaters	P-MON	Potamogeton pulcher	Spotted Pondweed
General Standing Water	Warm	Pool	shallow water	P-FER	Isoetes engelmannii	Engelman's Quillwort
General Standing Water	Warm	Pool	shallow water	P-MOS	Sphagnum macrophyllum	Large-leaved sphagnum
General Standing Water	Warm	Pool	submerged roots	P-DIC	Nymphaea odorata	Southern Fragrant Waterlily
General Standing Water	Warm	Pool	submerged roots	P-MON	Vallisneria americana	Eelgrass
Lentic	Cold	Pool		FISH	Hypentelium nigricans	Northern Hogsucker
Lentic	Cold	Pool		FISH	Oncorhynchus mykiss	Rainbow Trout
Lentic	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Ambloplites rupestris	Rock Bass
Lentic	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Lepomis macrochirus	Bluegill
Lentic	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Micropterus dolomieui	Smallmouth Bass
Lentic	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Micropterus salmoides	Largemouth Bass
Lentic	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Pomoxis annularis	White Crappie
Lentic	Warm	Pool	natural aquatic vegetation	FISH	Perca flavescens	Yellow Perch
Lentic	Warm	Pool	pools/backwaters	FISH	Perca flavescens	Yellow Perch
Lentic	Warm	Pool	skip	FISH	Oncorhynchus mykiss	Rainbow Trout
				FISH	Stezostedion vitreum	Walleye (Native population)
				AMPHIB	Necturus maculosus	Mudpuppy
				BIRD	Aix sponsa	Wood Duck
				BIRD	Haliaeetus leucocephalus	Bald Eagle
				BIRD	Lophodytes cucullatus	Hooded Merganser
				BIRD	Podilymbus podiceps	Pied-billed Grebe

07/15/2003

Viability Assessment Report
For
Lotic Water (Streams)

Prepared by
Victoria R. Bishop
Daniel Boone National Forest

I. Description of the Habitat Association

The Daniel Boone National Forest (DBNF) manages between 6 to10 percent of the Kentucky portion of the Ohio River Basin, consisting of portions of the Licking River Basin, the Kentucky River Basin, and the Cumberland River Basin (USDA Forest Service, 2001). In each case, only the upper to mid portion of the basin is within the DBNF. Each one of these systems is divided into numerous sub-systems called HUC (Hydrologic Units) delineations. Most of the 7,400 miles (GIS generated) of ephemeral, intermittent, and perennial streams located within the Forest are considered warm water, but some fall into the cool or cold categories. The streams range from slow meandering streams with low gradient, alluvial fan-shaped valleys to high gradient, high velocity streams in steep v-shaped valleys. Stream banks are sparsely to heavily vegetated with undercut banks are one of the most prominent features. Stream substrates range from fine silt/mud to large boulder fields with various combinations of the intermediate substrate classes. Three main divisions of habitat found within the streams are classified as riffles, glides, and pools, which occur in most streams in various combinations. Stream flow ranges from still, stagnant pools to fast roaring rivers with depth ranging from subsurface to tens of feet depending upon seasonal variability. Some streams include insurgences, resurgences, or both.

Warm water (80 to 85^{0}F summer and 40 to 60^{0}F winter – USDA Forest Service, 1988) streams range from slow meandering streams with low gradient, alluvial fan-shaped valleys to high gradient, high velocity streams in steep v-shaped valleys. Three main divisions of habitat found within the streams are classified as riffles, glides, and pools, which occur in most streams as various combinations. Stream flow ranges from still, stagnant pools to fast roaring rivers with depth ranging from subsurface to tens of feet. Some streams included insurgences, resurgences, or both.

Cool water streams on the Forest are found where the transition from cold to warm water occurs or where forest and streamside cover is dense enough to moderate water temperatures. Although some species of fish occurring on the Forest are considered cool water species, e.g., Blackside Dace, these same species can be found in all three temperature ranges. Cool streams generally have fairly steep gradients and narrow channels with little to no meandering. They often flow down into alluvial fan-shaped valleys to merge with larger, warmer streams. Often, small waterfalls occur at the sharp changes of gradient.

About 89 miles (mileage from USGS 7.5' quadrangles) of stream consisting of entire streams or shorter stream sections are considered to be coldwater habitat (50 to 70^{0}F – summer, < 58^{0}F – winter; USDA Forest Service, 1988). Forest streams considered cold water include

Tripplett Creek, Middle Fork Red River, East Fork Indian Creek, Big Double Creek, Little Double Creek, War Fork, Swift Camp, Cane Creek, Bark Camp Creek, Hawk Creek, Craney Creek, Dog Fork, and Rock Creek. Most of these streams could double as cool water streams as their temperatures vary with season and are kept cool due to the dense vegetation covering the streams in the headwaters. All of these streams presently contain and/or are stocked periodically with trout. A few of the streams were unofficially stocked with brook trout in the early 1980s. These streams generally have fairly steep gradients and narrow channels with little to no meandering. They often flow down into alluvial fan-shaped valleys to merge with larger, warmer streams. Often, small waterfalls occur at the sharp changes of gradient.

Karst habitat and associated streams within the DBNF proclamation boundary consists of a wide range of situations. Habitat generally is associated with limestone geology and ranges from caves with underground water systems to springs, sinks, sinkholes, resurgences, and subsurface interstitial flows. The aquatic habitat in karst areas tends to be cool to cold water, generally lacking phytoplankton or other plants requiring sunlight. There is also little to no perceivable light and wide variations of water flow.

- **Location**

  Streams are found throughout the DBNF. They occur in every Land Type Association (LTA) found on the forest (USDA Forest Service, 1997). All forest streams are part of the upper or middle Licking River Basin (Morehead Ranger District), or the upper to middle Kentucky River Basin (Stanton, London, Redbird Ranger Districts), or the upper to middle Cumberland River Basin (London, Somerset, Stearns Ranger Districts).

- **Geology and Soils**

  The following are the geologic descriptions of each of the contributing basins.

  A. Cumberland River Basin

  The DBNF portions of the Cumberland River Basin are found entirely on sedimentary rocks consisting of Mississippian and Pennsylvanian aged limestones, siltstones, shales, mudstones, coals, sandstones, and conglomerates. These sedimentary rocks are bedded and interbedded, with a slight dip to the southeast. Eastern portions of the DBNF are generally capped in Pennsylvanian rock, both resistant and often cliff or outcrop forming sandstone or conglomerate, or soft shales, siltstones, and coals. Most of the DBNF portion of the basin lies on these rocks. The portion of the DBNF along the western escarpment is similar, but with the addition of Mississippian rocks on some ridges and in many valleys. Karst solution is responsible for sinkholes and caves in some of these larger valleys. Flash floods and stream incision also shape the entire landscape.

  Soils range from clay loams to sandy loams to rock in the Pennsylvanian bedrock areas. Soil series such as Wernock, Gilpin, Lily, Shelocta, Jefferson, and Alticrest are typical. Some such as Shelocta and Jefferson are highly erosive and contribute to natural background sedimentation in streams. In the Mississippian bedrock areas, Caneyville, Sequoia and Berk series are common. Large areas of Fairpoint soils are present on surface mines.

B. Kentucky River Basin

The DBNF portions of the Kentucky River Basin are found entirely on sedimentary rocks consisting of Devonian, Mississippian, and Pennsylvanian aged limestones, siltstones, shales, mudstones, coals, sandstones, and conglomerates. These sedimentary rocks are bedded and interbedded, with a slight dip to the southeast. Eastern portions of the DBNF are generally capped in Pennsylvanian rock, resistant, and often cliff or outcrop forming sandstone or conglomerate, or soft shales, siltstones, and coals. About two-thirds of the DBNF portion of basin lies on these rocks. Along some larger tributaries of the Kentucky River, in particular the Red River and Red Lick Creek, bedrock is similar, but with the addition of Devonian and Mississippian rocks on some ridges and in many valleys. The more western portions of this basin on the DBNF also have the addition of Devonian and Mississippian bedrock. Karst solution is responsible for sinkholes and caves in many of these larger valleys. Flash floods and stream incision also shape the entire landscape.

Soils range from heavy clays to sandy loams to rock in the Pennsylvanian bedrock areas. Soil series such as Wernock, Gilpin, Shelocta, Cutshin, Jefferson, Steinsberg, and Alticrest are typical. Some, such as Shelocta and Jefferson, are highly erosive and contribute to natural background sedimentation in streams. In the Mississippian bedrock areas, Caneyville, Brownsville, and Berk series are common. Devonian bedrock areas, usually on lower slopes and rarely on low hills, have soil series such as Trappist and Colyer, both of which tend to be acidic. Extensive areas of Fairpoint soils are present on surface mines.

C. Licking River Basin

The DBNF portions of the Licking River Basin are found entirely on sedimentary rocks consisting of Devonian, Mississippian, and Pennsylvanian aged limestones, siltstones, shales, mudstones, coals, sandstones, and conglomerates. These sedimentary rocks are bedded and interbedded, with a slight dip to the southeast. The eastern portions of the DBNF are generally capped in Pennsylvanian rock, both resistant and often cliff or outcrop forming sandstone or conglomerate, or soft shales, siltstones, and coals. About one-half of the DBNF portion of the basin lies on these rocks. Western portions of the DBNF are similar, but with the addition of Devonian and Mississippian rocks on many ridges and in many valleys. Karst solution is responsible for sinkholes and caves in a few of these larger valleys. Flash floods and stream incision also shape the entire landscape.

Soils range from heavy clays to sandy loams to rock in the Pennsylvanian bedrock areas. Soil series such as Wernock, Shelocta, and Alticrest are typical. Some such as Shelocta are highly erosive and contribute to natural background sedimentation in streams. In the Mississippian bedrock areas, Caneyville, Bledsloe, Gilpin, Carpenter, and Berk series are common. Devonian bedrock areas, usually on lower slopes and rarely on low hills, have soil series such as Trappist and Colyer, both of which tend to be acidic.

- **Hydrology**

The State of Kentucky has over 89,000 miles of perennial rivers and streams (Kentucky Division of Water 1998). Approximately 7,400 miles lie within the proclamation boundary of the Daniel Boone National Forest. In addition to the perennial stream miles, there are approximately 34,600 miles of ephemeral and intermittent streams within the proclamation boundary (USDA Forest Service, 2001). None of the three major river basins is entirely contained within the DBNF proclamation boundary although the forest does have substantial influence on all three. Descriptions of the basins follow.

A. Cumberland River Basin

The Cumberland River Basin is composed of three major sections, the Upper, the Middle and the Lower Cumberland Rivers. The Lower Cumberland River section does not run through the DBNF, however, the Upper and Middle Cumberland River sections do. Only the latter two sections are discussed. The river mainstem flows approximately 308 miles from its origin west to southwest through a gap in Pine Mountain and across the Cumberland Plateau and Highland Rim before entering Tennessee near the southeastern corner of Monroe County. (USDA Forest Service, 2001)

1. Upper Cumberland River Basin

The Upper Cumberland River Basin includes about 1,977 sq mi above Cumberland Falls within the proclamation boundary (USDA Forest Service, 2001). The mainstem of the river starts at the confluence of Clover Fork and Poor Fork near Harlan, Kentucky. The river drains the Cumberland Mountains to the southeast and the Pine Mountain Overthrust to the northwest. Major tributary drainages joining the Cumberland from the north include Straight, Stinking, Richland, and Watts Creeks. Southern tributaries include Clear Fork, and Jellico and Marsh Creeks, all of which originate in Tennessee.

Flowing north, the river enters the DBNF proclamation boundary and eventually reaches Cumberland Falls near the mouth of Marsh Creek. Cumberland Falls drops 55 ft. It is thought to have been originally at Burnside, Ky. but through upstream progression (over thousands of years) obtained its present position, approximately 45 miles upstream of Burnside (USDA Forest Service 2001).

Generally, the streams in this river basin have moderately wide, flat valleys with some floodplain development. Gradients are moderately high with occasional perched wetlands in the headwaters of the streams. Larger streams lie within broad, alluvial bottoms. Drainage flow patterns are dentritic (USDA Forest Service 1997a). Low flow season usually occurs in June through September, and with an increase of precipitation in November, high flows begin. Extensive reaches of the Cumberland River mainstem and it's larger tributaries flow over bedrock and contain long boulder- and cobble- strewn shoals, and deep, rocky pools (USDA Forest Service 2001).

2. Middle Cumberland River Basin

Much of the Middle Cumberland River drainage lies in the Highland Rim section of Kentucky and Tennessee and a portion drains the Cumberland Plateau (USDA Forest Service 2001). Approximately 10 percent, roughly 5,016 sq mi, of the Kentucky portion of the Middle Cumberland River is within the DBNF proclamation boundary. This section of the river has two major dams, one built on the mainstream, and one built on a major tributary. Lake Cumberland is a 50,250-acre reservoir that backs up the lower reaches of tributaries upstream to the confluence of Laurel River. The dam (Wolf Creek Dam) for Lake Cumberland is located in southwest Russell County at Jamestown, Ky. Laurel River is impounded above its confluence with the Cumberland River creating a 6,060-acre reservoir. This area of the Forest is heavily forested and scenic and contains some of the better quality waters remaining in the state (USDA Forest Service, 2001).

Many of the streams in this area have narrow, flat valleys and moderately low gradients. First and second order streams often create perched wetlands. Stream flow varies with seasonal variation in rainfall and drainage flow patterns are dentritic. Low flow season usually occurs in June through September, and with increase of precipitation in November, high flows begin (USDA Forest Service, 1997).

B. Kentucky River Basin

The Kentucky River Basin headwaters originate in the rugged mountain area along the Pine Mountain Overthrust on the Cumberland Plateau. Approximately 6 percent of the 6,966 sq mi basin is managed by the DBNF . The river mainstem flows north-northwest approximately 256 miles from the origin at the North, Middle, and South Forks confluence, through the Bluegrass before emptying into the Ohio River near Carrollton. Some of the major tributaries to the Kentucky River include Eagle and Elkhorn Creeks, and the Dix and Red Rivers. Only portions of Eagle Creek, Elkhorn Creek and Red River are within the proclamation boundary.

"The streams and rivers of the basin have been characterized as upland" however, many smaller streams in the Bluegrass section are intermittent, and have hanging valleys up to their confluence with the mainstream. The mainstream itself is impounded by locks and dams (several are within the proclamation boundary) that extend from near the mouth upstream to Beattyville. The pooling of much of the mainstream and the lower reaches of many tributaries resulted in the loss of most riffle and shallow water habitat."(USDA Forest Service, 2001; p10.)

The Kentucky River Basin runs through several LTAs as noted above. In these associations there can be a moderate to high number of small to medium sized intermittent and perennial streams and rivers. Drainage patterns are dendritic with minor karst influence in the western portion of the DBNF. Low flow season usually begins in June through September and with an increase of precipitation in November high flows begin (USDA Forest Service, 1997).

C. Licking River Basin

The Licking River Basin starts on the Cumberland Plateau in Magoffin County and flows north – northwest through the Bluegrass for approximately 310 miles before emptying into the Ohio River near Covington. The DBNF contains approximately six percent of the basin, or about 3,707 sq mi. The two major tributaries, the North and South Forks, join the mainstem near Milford and Falmouth, respectively. The river basin is bound on the north and northeast by the Ohio River, Kinniconick Creek, Tygarts Creek, and the Little Sandy River drainages. The Kentucky River drainage bounds the south and southwest. Cave Run Lake is an 8,270-acre reservoir dammed near Morehead on the Licking River within the proclamation boundary. This reservoir impounds the mainstream in addition to lower reaches of several tributaries. "The creeks, streams, and rivers of the basin are generally upland, having moderate- to high- gradients, well-developed riffles and shoals, rocky substrates, and poor to moderate floodplain development"(USDA Forest Service, 2001; p.11).

This basin has a moderate number of small to medium sized intermittent and perennial streams and rivers. Riparian zone development on larger streams ranges from broad, flat valleys with well developed floodplains and moderately high gradients to wide valleys and low gradients. Flash flooding and high runoff in high gradient areas usually augmented the flows. Sluggish, long-standing water may cover large areas in the lower gradient floodplains (USDA Forest Service 1997).

II. Current Status of the Habitat Association on the Daniel Boone National Forest

Eastern Kentucky's landscape has changed dramatically since the late 1800's, when the dominant use of land was small scale subsistence farming. In the early 1900's, logging and agriculture clearing escalated until most of eastern Kentucky was cleared by the mid 1930's. Land acquisition for the DBNF (at that time known as the Cumberland National Forest) occurred with the establishment of the Weeks Act. Many people sold or abandoned their land to the Federal Government. The coal mining industry became prominent between the 1920's and the 1970's. Lands adjacent to federally managed land were stripped and deep mined. Extensive mining operations resulted in the loss of topsoil, high rates of stream sedimentation, and degradation of aquatic habitats and faunal communities.

Within the proclamation boundary there is approximately 260 miles of stream that has been designated by the Commonwealth of Kentucky as unable to support or partially support beneficial uses. "Sedimentation and acid mine drainage from abandoned surface and underground coal mines, brine and oil residue from oil drilling, sedimentation and runoff of agricultural chemicals and animals wastes from farm land, discharge from domestic wastewater systems, and sedimentation from roads and timber harvest constitute the primary water quality issues" in addition to the vast increase of recreational use by the people of Kentucky as well as neighboring states (USDA Forest Service, 2001 p. 42).

Due to the fragmentation of ownership within the DBNF proclamation boundary, it is difficult to manage or restore streams that are not entirely within National Forest ownership. While many private landowners are willing to participate in the restoration of streams running through their lands, most are not financially able to do so. Many landowners adjacent to the Forest Service are absentee owners meaning that they own the land, but do not live on the land. Many of these owners live in different states and are difficult to reach. These types of situations make extremely difficult the management of streams and the habitat they provide.

III. Management Needs: Recommendations for the Conservation of Habitat to Ensure Species Viability

The management goals for the Lotic Habitat Association (warm, cool, cold, and karst water) are to maintain the physical and microclimate conditions that will result in a high likelihood that species within this association will persist on the Forest over the planning period. Generally speaking, management designed to benefit one aquatic species in any particular watershed usually will benefit most if not all of the aquatic species in that watershed. Additional goals for streams in general is to be managed so that the CWD load is 125 to 300 pieces per stream mile (to be corrected when surveys dictate that this range should be changed). Waters generally run at or above a six mg/l level of dissolved oxygen however there are some that naturally run lower. Normally the desired dissolved oxygen level for streams is six mg/l or higher.

Restoration and maintenance of various physical components of the aquatic resources such as the sediment regime including timing, volume, rate, character of sediment input, storage and transport is vital. The spatial and temporal connectivity within and among the watersheds are also important. The chemical and physically unobstructed routes used by many species in their life histories are more important components.

The strategy to accomplish these goals mainly focuses on maintaining zones of limited disturbance around the habitat association. Additional standards and guidelines are also recommended when other protective measures are needed to insure the viability of a particular species associated with this habitat association. Many of the goals or desired future conditions of undisturbed zones consist of various aspects of the aquatic habitat. Maintenance of aquatic native biodiversity as well as water quality, food and habitat for all life stages of native aquatic life and riparian-dependent species must be established. Not only is the aquatic fauna of concern but so is the physical integrity of the aquatic systems including all aspects of the stream channel and riparian area. Some of these aspects are streambanks, substrate, and shorelines. While native aquatic biodiversity is of main concern exceptions can be established for desired non- native sport fish species but not to the detriment of the native species viability.

The biological components for restoration and maintaining the Forest's native species composition as well as the riparian and wetland plant communities are just as important as the physical and chemical components. They provide thermal regulation, nutrient filtering, appropriate erosion rates of surface and bank, and sufficient amounts and distributions of course woody debris (CWD) to sustain physical habitat complexity and stability.

Recommended standards and guidelines follow that will allow the Forest to strive toward the goals and desired future conditions mentioned above while maintaining the viability of the aquatic species found within it.

Habitat Association Standards and Guidelines

Unless otherwise stated all of the general directions, standards, and guidelines are obtained from "An Assessment and Strategy for Conservation of Aquatic Resources on the Daniel Boone National Forest, Interim Report, April, 2001". Whenever further clarification is needed for a particular statement please refer to the aforementioned document.

- Riparian Management Area (RMA):

  Naturally occurring CWD in streams is removed only when it poses a significant risk of damage to facilities or bridges and culverts. The need for removal is determined on a case-by-case basis by the Forest Fisheries and/or Hydrologist.

  - *Rationale: CWD in streams is needed in a variety of ways. It provides shelter for some, provides an area where the water is slowed or pooled and scouring occurs to create some pools, and it is part of the River Continuum Theory (Vannote et al 1980) in providing the fundamental organic needs of the stream. Only when in danger of damaging facilities such as bridges or culverts may CWD be removed.*

- Maintain, establish, or mimic natural flows wherever possible.

  - *Rationale: Stream flow is important for maintaining natural communities. Seasonal variations may trigger reproduction or maintain habitat. The presence of dams and locks may alter these natural patterns, and therefore affect species viability.*

- Instream use of heavy equipment is limited to the amount of time necessary for completion of the project and must be approved on a site-specific bases by the Forest Fisheries Biologist or Hydrologist.

  - *Rationale: Although sedimentation, over various levels, is considered detrimental for most aquatic species some necessary sedimentation (for a short period of time) occurs when heavy machinery is in the creek in order to try to prevent a continual source (or a long period of time) of sedimentation.*

- Off-Highway Vehicles (OHV's), bicycles, horses, and other non-pedestrian modes of transportation are prohibited within the RPA except at designated crossings.

  - *Rationale: These particular recreational activities create erosion processes above normal when done in the riparian protection areas. In some cases these activities can be quite detrimental to both the riparian habitat and stream fauna via erosion and levels of sedimentation and the possibility of crushing/compacting.*

- Vegetation Management can occur in riparian areas only when done for the sustainability or enhancement of riparian dependent species.

  - *Rationale: While removal of trees within the riparian areas is generally discouraged there are times when to create a desired future condition to benefit the fauna living within the riparian areas it may become necessary to remove some trees. However, the desired condition for the riparian areas must be maintained/considered before choosing to do so.*

- If tree removal is to take place within areas adjacent to the RMA and has to cross the RMA, cable logging is to be done but only after consultation with and approval by DBNF biologists or hydrologists. Full suspension is required when yarding logs across the RMA.

  - ***Rationale**: Site by site analysis needs to be considered because of the likelihood of the end of the logs being dragged and creating disturbance leading to erosion and sedimentation in the riparian area. Requiring full suspension when yarding logs prevents any dragging of logs across creeks and their banks creating disturbances and possible sources of erosion and sedimentation.*

- Fish stocking may be permitted as long as populations of native aquatic species are maintained or enhanced.

  - ***Rationale:** While the stocking of some non-native fishes maybe desirable for recreational purposes the native fauna needs and requirements must be the primary concern.*

- Fish stocking will not be permitted within the Cumberland River Drainage if the stocking will reduce viability of native aquatic species.

  - ***Rationale:** The Cumberland River system contains many species with restricted ranges which are known to be negatively impacted by fish stocking.*

- Drilling pads and production facilities for oil, gas, or mineral extractions are located outside of the RMA, for federally controlled minerals. Removal of mineral materials from within the RMA or stream channels is prohibited.

  - ***Rationale:** Production facilities and drilling pads located in the riparian area pose immediate hazards for aquatic habitat and fauna. The construction of such creates changes in the riparian area that can indefinitely change the processes and have an increased chance of sedimentation, spillage of extracted minerals and by-products that could greatly harm the aquatic fauna and its habitat.*

- Trails, campsites, and dispersed recreation sites are located, constructed, and maintained to minimize impacts to stream and riparian values.

    - ***Rationale****: Careful construction and consideration of location for recreational facilities can greatly minimize any impacts to the aquatic fauna and its habitat. Impacts such as sedimentation, pollution, crushing, compacting, and erosion are some of the impacts that can be avoided.*

- Recreational developments causing unacceptable resource damage are closed and/or rehabilitated. Soils are stabilized on eroded recreational sites through revegetation, traffic control, hardening (e.g. gravel, mulch), or site closure.

    - ***Rationale:*** *Sedimentation is one of the major detriments to aquatic fauna and should be minimized as much as possible. One way to do so is to restore or completely close some of the recreational sites.*

- Generally, impoundments are prohibited, but they may be approved on a site-specific basis.

    - ***Rationale:*** *Impoundments have been stated as one of the major causes for mussel decline over the last century. Generally, impoundments are detrimental for native fauna.*

- Filter strips are left between areas of severe soil disturbance (roads, landings, bladed skid trails, and constructions sites) and lakes, wetlands, and sink holes.

    - ***Rationale:*** *Filter strips filter surface runoff, trap sediment, and filter and absorb pollutants before entering an aquatic system.*

- The Riparian-Aquatic Management Area (RMA) that this direction applies to is a fixed area having variable width as follows:

    - The RMA width along <u>perennial</u> streams will be the 100 year floodplain, or 66 ft.[1], whichever larger.

    - The RMA width along <u>intermittant and ephemeral streams showing signs of annual scour</u> will be the 100 year floodplain, or 33 ft., whichever larger.

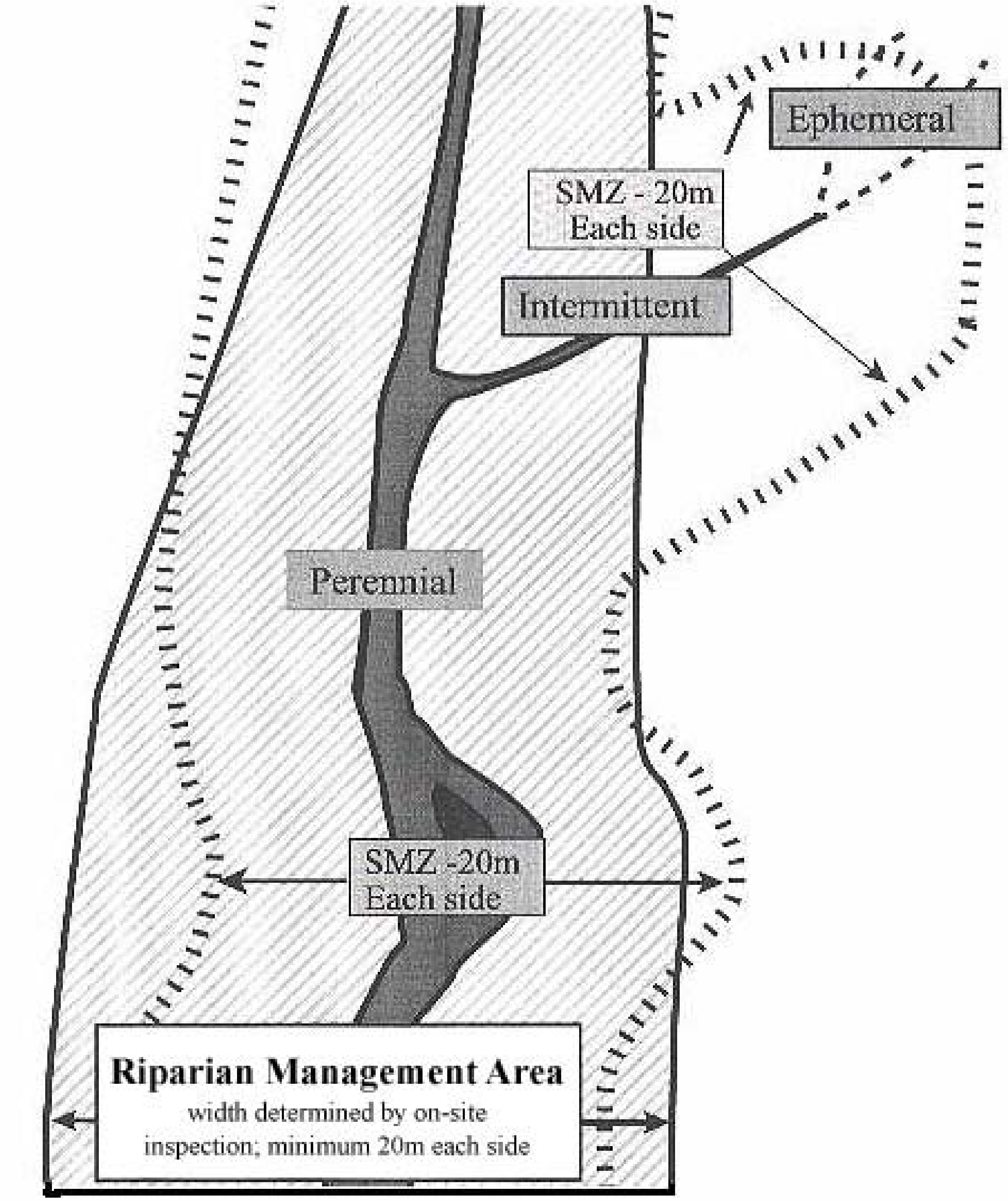
[1] Horizontal distance (feet), from the top edge of the stream banks, along both sides.

Filter Strips:

- This will be a zone which may extend beyond the RMA of all perennial and intermittant streams. This zone will have a DFC of the adjacent management area, as modified with stream protection standards. This area is located as follows:

% Slope[2] =	0-10%	11-20%	21-50%	50%+
Distance[1] =	95’	115’	175’	215’

[2] Average slope from the top edge of the bank to a point 100 feet up the slope at right angles to the contour.



Riparian Management Area and Streamside Management Zone in relation to perennial, intermittent, and ephemeral stream channels.

Vegetation Management – Forest Wide

Landings

Landings will be located outside the RMA and SMZ's, and away from ephemeral drainages. When no alternative to locating a landing in a SMZ is possible, additional mitigating practices will be required.

- ***Rationale:*** *Concentrated vehicle traffic on landings may result I soil compaction and rutting. As a result, storm water flows and erosion usually increase and runoff may contain toxic materials from fuels and lubricants in addition to sediment. BMPs should prevent drainage water and associated pollutants from entering streams or affecting subsurface water quality.*

Select sloping or side-ridge sites that provide drainage from the landing surface.

- Select and develop landing areas that require the least soil disturbance (Larse, 1971; Yee and Roelofs, 1980).
    - ***Rationale:*** *Heavy vehicle use on landings compacts soil and increases runoff (Golden and others, 1984).*
- As a result of any management activity ensure that runoff infiltrates and does not reach stream channels. Disperse storm water drainage over a convex slope so it does not concentrate in or above ephemeral channels.
    - ***Rationale****: This allows the sediment ladened runoff to disperse its load in a filter strip rather than in the water.*
- Avoid repeated use of a wet landing or using a landing when the ground is thawing.
    - ***Rationale:*** *The ground is at its most vulnerable state for erosion and runoff at this time.*
- Grade surfaces to smooth ruts and restore drainage paths (Rothwell, 1978).
    - ***Rationale:*** *Having smoother surfaces and well defined drainage paths allows the runoff to disperse over a filter strip and deposit any sediment or contaminant.*
- Add gravel or other surfacing materials to problem sites (Arola and others, 1991).
    - ***Rationale:*** *Adding gravel or other surfacing materials slows down any cutting/scouring action of flowing water and reduces the amount of sedimentation.*

- Service motorized equipment without spilling fuel or oil. Collect and remove waste oil, garbage, and trash.
    - ***Rationale:*** *Carrying through with this recommendation allows less to no chance of any of the fuel or oil (if spilled by accident) to enter the water.*
- Where landings are subject to erosion or are potential sources of sediment, vegetate landing areas immediately after construction, and revegetate as soon as use ends and maintain the site until the site is stable and no longer has the potential for accelerated erosion. Use native plants wherever possible.
    - ***Rationale****: This action decreases chances of sedimentation occurring or erosion to become a problem after the project is completed. By using native plants there should be no competition between plants and no introduction of possible exotic problem plants.*
- When necessary, rip all landings to ensure soil productivity and the successful reestablishment of vegetation.
    - ***Rationale****: This process will ensure the rapid growth of vegetation and reduce sedimentation.*

Skidding – Forest Wide

- Determine and mark skid trail routes prior to beginning operations, as part of preharvest planning. Avoid wetlands and poorly or somewhat poorly drained soils.
    - ***Rationale:*** *The careful location, use, protection, and closure of skid trails can significantly reduce soil exposure, soil movement, and sediment delivery to adjacent streams and other water bodies. Repeated traffic over a skid trail system can increase soil exposure, compaction, rutting, and risk of soil movement.*
- To minimize the width and number of skid trails and the area of soil exposed, landing placement and the skid trail system should be planned at the same time.
    - **Rationale:** *The careful location, use, protection, and closure of skid trails can significantly reduce soil exposure, soil movement, and sediment delivery to adjacent streams and other water bodies. Repeated traffic over a skid trail system can increase soil exposure, compaction, rutting, and risk of soil movement.*
- Skid trails and other ground-disturbing activities should not constitute more than 10 percent of the harvested area.
    - ***Rationale:*** *The careful location, use, protection, and closure of skid trails can significantly reduce soil exposure, soil movement, and sediment delivery to adjacent streams and other water bodies. Repeated traffic over a skid trail system can increase soil exposure, compaction, rutting, and risk of soil movement.*

- Skid trails should follow contours wherever possible, and skidding should be restricted to marked trails.
    - ***Rationale:*** *This action reduces sedimentation/soil movement.*
- Generally, skid trails should be diffused and approach landings from downslope, allowing water on trails to disperse onto less-disturbed downslope areas. If downhill skidding must be used, design and maintain drainage and dispersal structures to divert flow into undisturbed areas.
    - ***Rationale:*** *This action reduces sedimentation/soil movement.*
- Avoid blading skid trails. Minimize width and depth of blading where it is necessary to remove obstructions and provide safe access for ground-based equipment within the harvest unit.
    - ***Rationale:*** *The more ground disturbance there is the more chances for potential erosion and sedimentation runoff.*
- Skid trails should be designed with grades of 15 percent or less. Skidding on steeper grades should only be allowed for short distances. Cable yarding systems should be used on steeper slopes, or where slope stability or sensitive soils are of concern. Logs should be suspended high enough to prevent damage to soil and water resources.
    - ***Rationale:*** *The more ground disturbance there is the more chances for potential erosion and sedimentation runoff.*
- Do not skid logs or other materials within perennial, intermittent, or ephemeral stream channels. Skid trails should not cross perennial or intermittent streams. If crossing a perennial stream is unavoidable, use a temporary bridge or other approved method. When crossing intermittent or ephemeral streams, approach at right angles to the channel and implement mitigating measures.
    - ***Rationale:*** *Skidding logs across any wet area (stream, bog, sink, etc…) enhances soil disturbance and potential erosion and sedimentation creation. Crossing intermittent or ephemeral streams at right angles reduces the detrimental effects to the streambed and banks.*
- To minimize tractor or skidder traffic on the site, directional felling should be used and skidder operators should pull cables to logs rather than driving to each log.
    - ***Rationale:*** *This action reduces soil exposure and potential erosion and sedimentation.*
- Avoid skidding over saturated soils. Conduct operations in dry seasons or during dry periods whenever possible. Although some rutting may occur under wet conditions,

proper layout, use, and maintenance of skid trails reduces and controls traffic on the site, decreasing the probability of severe rutting.

- o ***Rationale:*** *Ruts are depressions caused by the repeated passage of vehicles over roads or trails. Ruts are conduits for water and sediment flow, which may enter streams and other water bodies or impede normal lateral water flow through soils or over the traveled surface. Rutting reduces soil macroporosity and saturated hydraulic conductivity which, in turn, may diminish the infiltration, drainage, and lateral flow capacity of the soil (Dickerson, 1976; Tippett, 1992).*

- Winch felled trees from areas of hydric or poorly drained soils. Avoid gouging or displacing soil.

  - o ***Rationale:*** *This action reduces soil exposure and potential erosion and sedimentation*.

- Remove and rehabilitate temporary stream crossings.

  Rationale: *Removing and "putting to bed" a temporary stream crossing reduces the possibility of it being used by others and the possibility of it eroding and creating sedimentation problems.*

- Add waterbars or other dispersal devices to direct storm water off skid trails and reduce potential sediment flow to streams (Lynch and others, 1985; Haupt and Kidd, 1965).

  - o ***Rationale:*** *Dispersal of storm water through these means reduces the chance of scouring, sedimentation, and erosion into streams.*

- Stabilize trails by scarifying or ripping, mulching, and seeding or planting. Use native plant species wherever possible.

  - o **Rationale***: This action decreases chances of sedimentation occurring or erosion to become a problem after the project is completed. By using native plants there should be no competition between plants and no introduction of possible exotic problem plants.*

Site Preparation – Forest Wide

Generally, only mowing and scarification are permitted; and then only on slopes with a sustained grade of less than 35 percent, or on sustained grades over 20 percent where there are highly erodible or failure-prone soils. Root-raking, shearing, and drum-chopping are not approved methods. Exceptions may include situations where a change in land use – from forestry to some other purpose – is planned, e.g., construction of developed recreation facilities and administrative sites, construction of wildlife openings, preparation of progeny test plantations, or rehabilitation of storm damaged areas.

- *Rationale*: *Mechanical site preparation treatments have the potential to cause soil compaction, erosion, and soil displacement; and they may adversely affect water quality by accelerating runoff and increasing sedimentation.*

- Ground-based mechanical equipment is not allowed with an RMA, SMZ, or any stream channel except at designated crossings.
  - ***Rationale:*** *Mechanical site preparation treatments have the potential to cause soil compaction, erosion, and soil displacement; and they may adversely affect water quality by accelerating runoff and increasing sedimentation.*

- No herbicide shall be aerially applied within 30 horizontal meters (100 horizontal feet), or ground-applied within 10 horizontal meters (30 horizontal feet) of lakes, wetlands, or perennial or intermittent springs (seeps) and streams; nor shall they be applied within 30 horizontal meters (100 horizontal feet) of any public or domestic water source. Selective treatments (requiring added, site-specific analysis and use of herbicides that have been approved for aquatic use) may occur within such buffers, but only to prevent significant environmental change such as to control noxious weeds. Buffers will be clearly marked before treatments, so applicators can see and avoid them.
  - ***Rationale:*** *Chemical treatments can have direct and indirect effects on fish and other aquatic flora and fauna. Direct effects result form a chemical, in active form and of sufficient concentration, coming in contact with fish or other aquatic biota through water, sediment, or food, causing a biological response.*

- If treating water and aquatic plants with pesticides, only approved pesticides for water use may be applied.
  - ***Rationale:*** *These activities are only to be used for riparian dependent species.*

- Aquifers and public water sources will be identified and protected. States will be consulted to ensure compliance with groundwater protection strategies.
  - ***Rationale:*** *Protection of public drinking water should be in compliance with the local state and federal groundwater protection strategies to ensure safe drinking water sources.*

- No pesticide (herbicide/insecticide) shall be broadcast or spread on rock outcrops or sinkholes. No soil-active herbicide with a half-life longer than 3 months shall be broadcast on slopes greater than 45 percent, erodible soils, or aquifer recharge zones. Such areas will clearly be marked before treatment, so applicators can easily se and avoid them.
  - ***Rationale:*** *Prevention of contaminate entrance into possible waterways or sub-terranean waters can only be accomplished by avoidance of rock outcrops or sinkholes and being broadcast on slopes less than 45 percent and vegetated.*

- Pesticide (herbicide/insecticide) mixing, loading, and cleaning areas in the field shall not be located within 60 m (200 feet) of wells, open water, or other sensitive areas.
    - ***Rationale:*** *Prevention of contaminate entrance into possible waterways or sub-terranean waters can only be accomplished by avoidance of rock outcrops, sinkholes, wells, open water, and other sensitive areas and being broadcast on slopes less than 45 percent and vegetated.*

Fire – Forest Wide

Wildfire – Forest Wide

- Use existing barriers, e.g., streams, lakes, wetlands, roads, and trails, to reduce the need for fire line construction.
    - ***Rationale:*** *The use of natural barriers should reduce the amount of sedimentation and erosion possibilities.*
- Fire retardants should not be applied directly over any water bodies.
    - ***Rationale:*** *The appropriate filter strip width should be sufficient to "filter" out contaminants in runoff. Avoidance of direct application (exception for personnel danger) of fire retardants to open water will reduce the effect that the fire retardant will have on the aquatic fauna. Retardants include un-ionized ammonia that is toxic to aquatic fauna when applied directly to water surfaces. However, an untreated strip along streams or lakes should be sufficient to virtually eliminate movement of retardant to aquatic system.*
- Fire lines, particularly those constructed with heavy equipment located within a RMA or a SMZ will be rehabbed and revegetated within one week time frame. Use seed mixture approved by Forest Botanist.
    - ***Rationale:*** *This reduces the amount of sedimentation ladened runoff that can enter the open water.*
- Constructed fire lines should be only as wide and deep as necessary to contain fire and remove flammable fuels.
    - **Rationale:** *The more ground disturbance there is the more chances for potential erosion and sedimentation runoff.*
- All fire lines will be waterbarred, or turnouts will be constructed as soon as practicable using the maximum spacing guidelines outlined in fire guidelines.

- *Rationale:* *Waterbars reduce the amount of runoff sedimentation by channeling the runoff to a filter strip where the particulates can be disposed of.*

- Waterbars should be installed by blading or plowing, if possible, when fire lines are constructed.
  - *Rationale:* *The effectiveness and stability that a mechanically established waterbar exhibits is better however still should not be done within the SMZ if at all possible.*

- Ensure waterbars and turnouts do not discharge into stream channels or sink holes.
  - *Rationale:* *By ensuring that the waterbars and turnouts do not discharge into stream channels or sink holes keeps as much sedimentation as possible out of the groundwater and open water channels.*

- Use hand-constructed fire lines on steep slopes and near stream channels whenever possible.
  - *Rationale:* *This action allows for the minimal ground disturbance as possible and less sedimentation.*

Prescribed burning – Forest Wide

- Use existing barriers, e.g., streams, lakes, wetlands, roads, and trails, to reduce the need for fire line construction.
  - *Rationale:* *This action reduces possibility of increase in erosion and sedimentation.*

- Burns must not consume all litter and duff or alter the structure and color of mineral soil on more than 20 percent of streamside areas. Steps taken to control soil heating will include the use of backing fires on steep slopes, scattering concentrated fuels, and burning heavy pockets of fuel separately.
  - *Rationale:* *Higher fire severity determines the extent to which the litter and humus layers are affected and the degree to which mineral soil is exposed.*

- Backing fires may be used in place of constructed fire lines in an SMZ, providing that such fires do not kill trees and shrubs that shade the stream. Such backing fires should burn at an intensity of less than 30 BTU's (British Thermal Units) per second per foot, or with a flame length of under 60 cm (2 feet).
  - *Rationale:* *Backing fires may be more effective than constructed firelines in reducing the potential for sediment to reach a stream.*

- On severely eroded forest soils, do not burn any area where the average depth of litter-duff is less than 1.25 cm (1/2 inch) or where forest soil depth is less than 50 cm (20 inches).
    - ***Rationale:*** *Erosion and nutrient-loss potential increase with steepness of grade and severity of the fire.*

Transportation System – Forest Wide

Roads and Road Systems – Forest Wide

- Road systems should be located on the most stable terrain and include the smallest-sized and lowest number of log decks, the shortest length of skid trails, and the fewest stream crossings.
    - ***Rationale:*** *The construction and use of roads necessitates soil disturbance and creates increased erosion potential. A wide variety of BMP's are available, many of which can reduce erosion potential or prevent sediment from reaching stream channels (Hewlett and Douglass, 1968; Kochenderfer and Aubertin, 1975; Lynch and other, 1985; Swift, 1988).*
- Roads should be located as close to slope contour as possible, avoiding landslides, springs, and seeps, as well as slopes at or exceeding the angle of repose, rock outcrops, sink holes, old gully systems, and other sensitive areas**.**
    - ***Rationale:*** *Planner's should recognize a proposed road's potential sediment sources. High-erosion hazard areas include steep, dissected slopes and landslides. Soil and rock characteristics, slope, and local hydrology influence erosion potential.*

Drainage – Forest Wide

- Avoid SMZ's, wet floodplain soils, and other locations where drainage cannot be provided.
    - ***Rationale****: To ensure good drainage and maintenance of its load-bearing strength, a road should be located on stable slopes, preferably along ridgetops with gentle side slopes.*
- Select road locations that avoid crossing or coming near streams or other water bodies, because all are part of the stream system.
    - ***Rationale:*** *Roads account for 90 percent of the sediment resulting from forestry activities (Eschner and Larmoyeux, 1963; Douglass and Swank, 1975; Ursic and Douglass, 1978; Yoho, 1980; Golden and other, 1984; Swift, 1985, 1993).*

- Do not route roads across perennial, intermittent, or ephemeral channels without providing a crossing structure or other mitigating measures that protect the channel from soil disturbance and the road from stormflow.
    - ***Rationale:*** *In general, new roads should be located outside the RMA and SMZ's. Roads should approach and cross stream channels at right angles, perpendicular to the flow of water, to minimize the amount of bare road surface and cut bank adjacent to the stream channel (refer to SMZ and Stream Crossing BMP recommendations).*
- Where roads must approach or cross stream channels, install sediment barriers (including filter strips) and employ appropriate stream crossing practices (refer to Sediment Barriers and Stream Crossings BMP). Do not locate roads in the floodplain parallel to streams. Approach stream channels on the contour and cross at right angles. Select stable channel-crossing sites.
    - ***Rationale:*** *In general, new roads should be located outside the RPA and SMZ's. Roads should approach and cross stream channels at right angles, perpendicular to the flow of water, to minimize the amount of bare road surface and cut bank adjacent to the stream channel (refer to SMZ and Stream Crossing BMP recommendations).*
- A sloping road approach to any stream crossing should have water-control structures, such as broad-based dips, to divert water from the roadbed and away from the channel (refer to Broad-Based Dips BMP). Alternatively, elevate the grade and create a berm along the shoulders of the roadbed at the crossing to drain surface water away from the stream.
    - ***Rationale:*** *This action minimizes influx of sedimentation to the water system.*

Road Locations – Forest Wide

- Avoid steep road grades (percent slope of the road centerline). Locate and design roads as close to the contour as possible.
    - ***Rationale:*** *To ensure good drainage and maintenance of its load-bearing strength, a road should be located on stable slopes, preferably along ridgetops with gentle side slopes.*
- Grades for access roads should be between 2 and 10 percent although steeper grades may be allowed for short (less than 200-foot) sections. However, road grades on soils with poor trafficability and high erosion potential should be adjusted downward accordingly. Switchbacks and frequent changes in grade are better than a sustained grade.

- *__Rationale:__ These actions are designed to minimize erosion and sediment ladened runoff.*

- Vertical road-cut slopes, which should be less than 3-foot high, can be used where outsloped roadbeds do not have an inside ditch. Vertical cuts in erodible material should not exceed 105 m (5 feet) high. Cut slopes between 1 and 2 m (3-6 feet) high should be constructed at a ¾ :1 grade, cuts higher than 2 m (6 feet) should be sloped to a 1:1 grade and immediately revegetated.

    - *__Rationale:__ Actions outlined in this section are designed to minimize erosion and sediment ladened runoff.*

Surfacing and revegetation – Forest Wide

- Until grass and other vegetation are well established, rock, erosion fabric, excelsior blanket, or mulches can protect temporary erosive fills at dip and cross-drain outlets, and at stream crossings.

    - *__Rationale:__ Immediately following construction on each section of road, all exposed soil in cuts, fills, and roadbeds should be seeded with grass or other recommended vegetation. These actions will reduce erosion and sediment ladened runoff.*

- A soil or gravel berm along the roadbed at the top of new, unprotected fills or at stream crossings can divert, spread, or filter stormwater leaving the roadbed until stabilized by vegetation.

    - *__Rationale:__ Actions outlined in this section are designed to minimize erosion and sediment ladened runoff.*

- Use stone or other stabilizing material to protect roadbeds on erosive soils and on steeper grades.

    - *__Rationale:__ Use stone or other stabilizing material to protect roadbeds on erosive soils and on steeper grades. Clean, 8 cm (3 inch) rock applied when the roadbed is soft will become embedded in the soil and provide a pavement for erosion prevention (Kochenderfer and Helvey, 1987).*

Road Drainage – Forest Wide

- Design frequent diversions into the roadway to reduce the erosive poser of storm water, and limit chances of off-road damage. Do not run drainage water into landslide-prone areas or onto large, loose fills.

    - *__Rationale:__ Actions outlined in this section are designed to minimize erosion and sediment ladened runoff.*

- Broad-based dips and outsloped roadbeds are commonly used to remove storm water from roads (refer to Broad-based Dips BMP). Inside ditchlines are recommended only to provide a gradient in flat terrain to drain roads.
    - ***Rationale:*** *Actions outlined in this section are designed to minimize erosion and sediment ladened runoff.*
- Where conditions allow, outslope the entire width of a road 3 percent toward the fill slope to obtain best surface drainage. For improved safety, roads may be flat (level graded) or insloped on sharp turns, steep grades, and slick soils; but roadbeds without ditchlines should be outsloped when reconditioned or closed. Broad-based dips spaced at frequent intervals should be used to divert surface water on insloped sections, or such water should be diverted to ditchlines and removed.
    - ***Rationale:*** *Actions outlined in this section are designed to minimize erosion and sediment ladened runoff.*

Design Strategies – Forest Wide

- Construct a steeper climbing road, e.g., up to the point of a ridge, and avoid all intermittent and ephemeral stream crossings.
    - ***Rationale:*** *Most road construction and management BMP's are techniques for intercepting drainage and sediment originating at roadways to keep it from entering ephemeral, intermittent, and perennial stream channels, rivers, and lakes.*
- Construct a climbing cross-slope road with some crossings on headwater streams.
    - ***Rationale:*** *Actions outlined in this section are designed to minimize erosion and sediment ladened runoff.*
- Construct a lower-gradient road where risks of roadbed erosion are less, but stream crossings are more frequent.
    - ***Rationale:*** *Actions outlined in this section are designed to minimize erosion and sediment ladened runoff.*

Broad-based dips – Forest Wide

Design – Forest Wide

- The dip should be designed/constructed in a way that the sediment that reaches the dip should pass through it and not deposited in the dip outlet.
    - ***Rationale:*** *Broad-based dips divert storm water from the road surface without accelerating erosion or delivering sediment to a stream.*

- Cross-ditches, water-bars, and open-topped drains are not alternatives to broad-based dips.
    - ***Rationale:*** *Such structures require frequent maintenance and when not maintained, they fail to divert storm water from the road surface, which increases road erosion and opportunities for sediment to reach streams.*

Installation – Forest Wide

- Neither the throat nor the hump should have a sharp, angular break.
    - ***Rationale:*** *When the dip is rounded, it allows the smooth flow of traffic.*
- The bottom or throat of the dip is outsloped 2 to 3 percent over the total width of the roadway. The throat of the dip should be at a right angle to the road centerline.
    - ***Rationale:*** *Actions outlined in this section are designed to minimize erosion and sediment ladened runoff.*
- In reconstruction, the 20-foot (6 m) (or longer) section, 3-percent reverse grade hump may be built from material excavated from the throat of the dip.
    - ***Rationale:*** *Actions outlined in this section are designed to minimize erosion and sediment ladened runoff.*

Stabilization – Forest Wide

- Use larger, clean, open-graded stone, 5 to 8 cm (2 to 3 inches) in diameter, rather than the more erosive "crusher run" material.
    - ***Rationale:*** *Use stone or other stabilizing material to protect roadbeds on erosive soils and on steeper grades. Clean, 8 cm (3 inch) rock applied when the roadbed is soft will become embedded in the soil and provide a pavement for erosion prevention (Kochenderfer and Helvey, 1987).*
- An energy absorber or runoff spreader should be installed below the outlet of the dip to dissipate runoff energy and spread the runoff, particularly where the land slope is steep.
    - ***Rationale:*** *This action dissipates the action or flow of the water spreading the erosive power over a greater area and allows the runoff to infiltrate the ground below and deposit its sediment.*
- Fillslopes below a dip outlet should be protected with grass, brush, erosion fabric, or rock.

- *Rationale:* *Sediment barriers below the dip outlet will slow the flow of storm waters and encourage early deposition of sediment on the forest floor.*

Proximity to streams – Forest Wide

- A broad-based dip should not be used to cross stream channels, nor should it drain into any perennial, intermittent, or ephemeral stream.
  - ***Rationale:*** *The objective of broad-based dips is to keep storm runoff and sediment out of the stream system (Swift, 1988).*

Spacing – Forest Wide

- Always construct dips upslope from steep road grades and stream crossings.
  - ***Rationale:*** *Actions outlined in this section are designed to minimize erosion and sediment ladened runoff.*
- Construct dips where the fill slope (distance from the outer edge of a road surface to edge of fill) is short, and where the topography provides surface obstructions and a terrain that will help spread the outflow.
  - ***Rationale:*** *This action minimizes sedimentation and erosion because of the dispersal of the flowing runoff. It does this by slowing down the water and spreading out its sediment load onto a broader field that it can infiltrate and deposit its material.*
- Avoid constructing dips I hollows, where fill slopes tend to be longer, and where outflow from the dip could be concentrated at the head of an ephemeral stream.
  - ***Rationale:*** *Actions outlined in this section are designed to minimize erosion and sediment ladened runoff directly into a stream body.*

Table 1. Approximate spacing between broad-based dips based on slope. Actual spacing depends o character of terrain adjacent to the road and other factors such as drainage patterns.

Road Grade	Space between dips	
%	Meters	Feet
4	60	200
6	50	165
8	45	150
10	43	140
12	40	135

Planning and Design – Forest Wide

- Turnouts and cross-drains must not empty into any type of stream channel.
  - ***Rationale:*** *Actions outlined in this section are designed to minimize erosion and sediment ladened runoff directly into a stream body.*
- Cross-drains should not empty onto fill material unless the fill slope is protected from erosion.
  - ***Rationale:*** *If cross-drains empty onto fill slopes, drop-outlet structures may be required to safely carry runoff over the fill.*
- Cannon, shotgun, or overhanging culverts should not be installed without an adequate energy dissipator below the outlet of the pipe.
  - ***Rationale:*** *Actions outlined in this section are designed to minimize erosion and sediment ladened runoff.*
- Runoff water should be spread, retained, or infiltrated below or beyond the outlet of a turnout or cross-drain. Sediment barriers should be used where runoff volume is large. Logs or brush placed on the ground surface – along the contour of the land – can be used where the expected volume of water and sediment is low.
  - ***Rationale:*** *Actions outlined in this section are designed to minimize erosion and sediment ladened runoff*
- Install turnouts and cross-drains at frequent intervals to prevent ditch flows from eroding ditch bottoms, cut slopes, or road edges.
  - ***Rationale:*** *This action minimizes sedimentation and erosion because of the dispersal of the flowing runoff. It does this by slowing down the water and spreading out its sediment load onto a broader field that it can infiltrate and deposit its material.*
- Use buried pipes for cross-drains. Do not use open-top culverts (wooden box or pole culverts), which require almost constant maintenance.
  - ***Rationale:*** *Open-top culverts rapidly fill with gravel and fine sediments and are prone to failure during rainfall events.*

Construction – Forest Wide

- The bottom of turnouts should intersect the ditch bottom at the same elevation.
  - ***Rationale:*** *Actions outlined in this section are designed to minimize erosion and sediment ladened runoff*

- The bottom of turnouts should be steep enough to prevent ponding of runoff and sediment deposition, but be flat enough to prevent erosion of the turnout bottom.
    - ***Rationale:*** *Properly installed turnouts and cross-drains safely route runoff, which accumulates in ditches and at the outlets of waterbars and broad-based dips, away from the road surface. Their purpose is to divert water to where it will infiltrate and drop its sediment load before reaching streams (Swift, 1985).*
- Stabilize all disturbed soils around turnouts and cross-drains as soon as practical. Establish vegetation on turnout bottoms only if it will not cause ponding or sediment deposition within the outlet.
    - ***Rationale:*** *Actions outlined in this section are designed to minimize erosion and sediment ladened runoff*
- The bottom of cross-drains should be installed at the same elevation as the ditch bottom.
    - ***Rationale:*** *Actions outlined in this section are designed to minimize erosion and sediment ladened runoff*
- Compact at least the lower portion of fill material surrounding cross-drains to prevent "piping" along the culvert. Cover the pipe with a minimum of 30 cm (12 inches) of soil or half the culvert's diameter, whichever is greater.
    - ***Rationale:*** *Compacted soil or fill material will inhibit erosion around the culvert and allow the sediment ladened runoff to be dispersed to other appropriate areas to infiltrate and deposit it load.*
- Cross-drain outlets or outfalls should have energy dissipators to prevent excessive erosion.
    - ***Rationale:*** *These structures do exactly what they are named for, energy dissipators. They break up the energy in the flowing water and allows time for the sediment to drop out.*

Stream Crossings – Forest Wide

Planning – Forest Wide

- Minimize the number of stream crossings.
    - ***Rationale:*** *Stream crossings are the most critical element of a transportation system. Improperly designed or constructed crossings can significantly increase sediment loading. Therefore, the fewer crossings the less sediment and erosion.*

- Locate stream crossings to minimize channel change and the amount of fill material needed.
    - ***Rationale:*** *Stream crossings are the most critical element of a transportation system. Improperly designed or constructed crossings can significantly increase sediment loading. Therefore, the few crossings the less sediment and erosion.*
- Select channel sections that are relatively straight (both above and below the crossing) and have stable banks and bottom.
    - ***Rationale:*** *Stream crossings are the most critical element of a transportation system. Improperly designed or constructed crossings can significantly increase sediment loading. Therefore, the few crossings the less sediment and erosion.*
- Avoid, construction during spawning seasons of sensitive aquatic species such as trout and mussels, or any threatened or endangered species.
    - ***Rationale:*** *Any extra sedimentation added to the stream could potentially cover or somehow influence the spawning procedures of different species and contribute to a poor spawning year and affect the viability of those species..*

Design (all types of crossings) – Forest Wide

- To minimize the length of streamside disturbance, align roadway approach sections with the stream channel at or near a right angle; cross the stream in the shortest possible distance.
    - ***Rationale :*** *Stream crossings are the most critical element of a transportation system. Improperly designed or constructed crossings can significantly increase sediment loading. Crossing at or near a right angle reduces the amount of stream banks disturbed.*
- Design the crossing to maintain stream hydraulics/turbulence. Minimize channel gradient changes, widening, or constriction.
    - ***Rationale:*** *Stream crossings are the most critical element of a transportation system. Improperly designed or constructed crossings can significantly increase sediment loading. Crossing at or near a right angle reduces the amount of stream banks disturbed.*
- Use crossings that do not disturb the bottom of stream, e.g., bridges or pipe arches, to minimize effects on fish or other aquatic organisms.
    - ***Rationale:*** *Any substrate disturbance, where physically dug up or covered by sedimentation, can effectively disturb aquatic organisms in one to many ways*

and could disrupt the life histories of those organisms to the point of endangered viability.

- For temporary roads, favor temporary bridges over culverts or fords.
    - ***Rationale:*** *If road runoff, sediment, or other pollutants enter the stream system, crossings also may become chronic point sources.*

      Therefore, the fewer crossings the less potential future damage.
- Design structures to accommodate storm flows expected to occur while the structures will be in place.
    - ***Rationale:*** *By using regionally accepted methods for calculating expected stormflows the appropriate sized structure can be utilized.*
- Design crossings so streamflow does not pond above the structure during normal or high flows.
    - ***Rationale:*** *If road runoff, sediment, or other pollutants enter the stream system, crossings also may become chronic point sources.*
- Design crossings to minimize the amount of road runoff that enters the stream.
    - ***Rationale:*** *If road runoff, sediment, or other pollutants enter the stream system, crossings also may become chronic point sources.*
- Design structures so that precipitation falling on the roadbed drains away from the stream.
    - ***Rationale:*** *If road runoff, sediment, or other pollutants enter the stream system, crossings also may become chronic point sources.*
- Divert surface runoff from crossing approaches as near to the crossing as possible without causing runoff to enter the stream.
    - ***Rationale:*** *If road runoff, sediment, or other pollutants enter the stream system, crossings also may become chronic point sources.*
- Design crossings to allow passage of floating debris and bedload.
    - ***Rationale:*** *If debris and bedload cannot pass through or over a crossing it will jam up and create a backflow of water that can potentially cause the blowout or demise of the structure. This in turn creates more erosion and sedimentation production.*

- Design the crossing so that streamflow will not be diverted along the road if the crossing fails, plugs with debris, or is over-topped.
    - ***Rationale:*** *If road runoff, sediment, or other pollutants enter the stream system, crossings also may become chronic point sources.*

      Overflowing streamflow can cause extremely large amounts of erosion to occur as well as large amounts of sedimentation being added to the stream.

Construction (all types of crossings) – Forest Wide

- All suitable excavated material shall be used as backfill or embankment. Dispose of all surplus material in a stable, protected area outside the floodplain**.**
    - ***Rationale:*** *This minimizes the chances of the backfill being diverted by runoff back into the stream as sedimentation.*
- Avoid operating machinery in any waterbody, including streams, whenever possible.
    - ***Rationale:*** *Equipment in the stream can potentially cause compaction of the substrate, crush any type organism at that particular point (such as mussels), create sedimentation and any other number of detrimental effects to aquatic life.*
- Do not place erodible fill material below the normal high water line unless the material can be stabilized. Stabilize erodible fill with material that will not be moved by normal or high streamflows.
    - ***Rationale:*** *This minimizes the chances of the backfill being diverted by runoff back into the stream as sedimentation.*
- Construct (install) crossings during dry weather and at times are not critical for the aquatic ecosystem.
    - ***Rationale:*** Constructing *the crossing with the appropriate BMP's keeps as much erosion and sedimentation to the minimum. Construction schedules should not occur with the November 15 and April 15 range due to intense storms are more likely to occur.*
- Use silt fences or other sediment barriers along the fill to minimize soil loss from the construction site.
    - ***Rationale:*** *These structures help minimize the amount of soil reaching the streams.*
- Immediately stabilize all exposed soils.
    - ***Rationale:*** *These structures help minimize the amount of soil reaching the streams.*

- Unless it is to be incorporated into a brush barrier, remove construction debris and other newly generated roadside slash away from stream and outside the SMZ. Take such material to a location mutually agreed upon by a DBNF hydrologist or fisheries biologist.
    - ***Rationale:*** *These structures help minimize the amount of soil reaching the streams.*

Pipe culverts and pipe arches – Forest Wide

- Under most conditions, culverts should be considered permanent installations and not removed after use. If culverts must be removed, stream banks and channel must be restored to their original contour (size and shape) and all disturbed soil stabilized.
    - ***Rationale:*** *Any time soil disturbance is done there is always the potential of erosion and sedimentation production. The fewer entry times the less potential of*
- Use one large culvert rather than two or more smaller ones whenever possible.
    - ***Rationale:*** *Larger pipes pass water more efficiently than small pipes and the latter are more easily plugged by floating debris.*
- Individual crossings should be constructed for each channel of a braided stream or across broad flats.
    - ***Rationale:*** *Additional culverts may be needed to maintain proper flow distribution on wet sites.*
- Align the pipe with stream direction and gradient to ensure that sediment passes through the pipe and that water is not directed against the streambank.
    - ***Rationale:*** *If road runoff, sediment, or other pollutants enter the stream system, crossings also may become chronic point sources.*

      Overflowing streamflow can cause extremely large amounts of erosion to occur as well as large amounts of sedimentation being added to the stream.
- Install the culvert bottom at the same level as the stream bottom. Where fish passage is a concern, use a pipe-arch culvert. If a pipe-arch culvert is not available, install the culvert with a gradient of 1 percent or less, unless special features are included to facilitate fish passage. If the pipe cannot be bedded using on-site material, excavate at least 20 cm (8 inches) and backfill to the natural level of the channel with approved material.
    - ***Rationale:*** *This allows for fish movement up and down the stream. An instance where this is important is for spawning and life threatening avoidance maneuvers.*

- Inlet and outlet ends of the pipe must extend beyond the fill.
    - ***Rationale:*** *This keeps the streamflow from eroding out around the culvert.*
- To prevent flow blockage or erosion and scour, protect pipe entrance and embankments with riprap, gabions, headwalls, drop inlets or other inlet structures.
    - ***Rationale:*** *Overflow of streamflow can cause extremely large amounts of erosion to occur as well as large amounts of sedimentation being added to the stream.*
- Control outlet scour below pipe culverts with energy dissipators that are compatible with fish passage requirements or movement of aquatic fauna.
    - ***Rationale:*** *These structures do exactly what they are named for, energy dissipators. They break up the energy in the flowing water and allows time for the sediment to drop out. However they need to be able to allow the passage of fish and other aquatic organisms for such reasons as spawning or life threatening avoidance maneuvers.*
- Culverts should be sized and installed to accommodate a minimum 20-year flood. Roadways must be protected from washout when overtopped by a flood event.
    - ***Rationale:*** *Overflowing streamflow can cause extremely large amounts of erosion to occur as well as large amounts of sedimentation being added to the stream.*
- Place culverts and culvert fills to prevent "piping" along the length of the culvert. Cover the culvert with a minimum of 30 cm (12 inches) or half the culvert's diameter of soil, whichever is greater.
    - ***Rationale*****:** *Compacted soil or fill material will inhibit erosion around the culvert and allow the sediment ladened runoff to be dispersed to other appropriate areas to infiltrate and deposit it load.*

Fords – Forest Wide

- Fords should be considered only where roads will receive minimum or intermittent use; and such use should be restricted to low-flow periods. Use fords only on service and minor collector roads, not arterials and major collector roads.
    - ***Rationale:*** *Crossings generate a sediment load and can, when not properly maintained, create potentially damaging erosion points. Fords will do this more so than a regular bridge type crossing.*
- When creating approach sections, select locations with stable and relatively low stream banks that will require minimal excavation and earth movement.
    - ***Rationale:*** *Less soil disturbance the less erosion and sedimentation production will occur.*

- Select only locations with bottom conditions that will support the designed use.
  - ***Rationale:*** *Geo-textile fabrics, precast concrete planks, or additional rock may be added to strengthen or armor the crossing bottom, if such materials will provide for acceptable movement of fish and other aquatic fauna. All BMPs should facilitate conformance with the contour and grade of the stream channel substrate.*

- Harden road approach sections within 8 m (25 feet) of the stream to prevent erosion and sediment delivery directly into the stream channel.
  - ***Rationale:*** *Compact surfaces or rocked surfaces allow the runoff to generally pass without greatly increasing the accumulation of sedimentation.*

- Construct the ford bottom so it is low in the stream center, rather than flat.
  - ***Rationale:*** *Generally, the stream bed is shaped so that it is lower in the center and to follow the stream bed and not impede the flow of water the ford bottom should follow suite.*

Bridges (permanent and temporary) – Forest Wide

- Discourage the use of low-water bridges
  - ***Rationale:*** *bridges that are above water during normal flows but are submerged during high flows because they can preclude movement of fish and other aquatic species.*

- Place abutments on firm material where they will not obstruct stream flow or reduce channel capacity.
  - ***Rationale:*** *When abutments obstruct stream flow or reduce channel capacity there will be the possible erosion and sedimentation production.*

- To avoid unnecessary site disturbance and soil erosion, remove only the stringers and decking after using temporary bridges. Do not remove abutments from temporary bridge installations even when the road is closed, obliterated, and reclaimed.
  - ***Rationale:*** *Any time soil disturbance is done there is always the potential of erosion and sedimentation production. The fewer entry times the less potential of erosion and sedimentation.*

Sediment barriers – Forest Wide

- Plan roads, landings, or other potential sources of soil disturbance so that sediment is released as far upslope from stream channels as possible. Select and design runoff outlets that will disperse water and sediment over the terrain and allow it to infiltrate.

- *Rationale:* This action reduces the amount of sediment reaching the stream.

- The use of one or more sediment barriers, including brush, will increase the sediment trapping capacity of a filter strip.
  - ***Rationale:*** *This action reduces the amount of sediment reaching the stream.*

- Concentrated flows of sediment and water from dips, culverts, and turnouts can be delayed and spread by traps constructed with hay or straw bales that are held in place by stakes. To be effective, bales must fit tight and close together on the forest floor or ditch surface.
  - ***Rationale:*** *This action reduces the amount of sediment reaching the stream.*

- Dikes of rock or layers of riprap, brush, or logs can be used to break the force of flowing water in ditches and at outlets of culverts and crossdrains.
  - ***Rationale:*** *This action reduces the amount of sediment reaching the stream.*

- Install silt fences with stakes on the downslope side. The number of stakes will depend on specific circumstances but in general more is better, to help hold the fabric and reduce the weight on each individual stake. Additional support of wire fencing of wire fencing may be necessary.

- Lay fabric against the upslope side of brush barriers to seal openings in the brush.
  - ***Rationale:*** *This action reduces the amount of sediment reaching the stream.*

- The bottom strip of all silt fences must be dug into the soil, facing upslope, or otherwise tightly attached to the soil surface along the full length of fence.
  - ***Rationale:*** *This action reduces the amount of sediment reaching the stream.*

- Position fences along the contour with ends turned upslope beyond the level where flow could bypass the barrier.
  - ***Rationale:*** *This action reduces the amount of sediment reaching the stream.*

- The soil surface can be protected from erosion by layers of excelsior blanket or other erosion-preventing fabrics, mulches, or rock layers. This practice is most appropriate where the volume or velocity of water discharged onto bare soil or the forest floor exceeds the ability of the surface to resist erosion. Materials used will have mesh large enough not entrap retiles, birds, etc…
  - ***Rationale:*** *This action reduces the amount of sediment reaching the stream. Small mesh sizes will trap reptiles and birds and effectively kill or maime.*

- Retention basins can be constructed to trap storm water and sediment. Preconstruction planning must consider the volume of water and material that will be retained, as well as the need for periodic cleaning of the basin to maintain its capacity.
    - ***Rationale:*** *Preconstruction planning allows for the time to get accurate streamflow data in order to construct the appropriate sized structure.*
- All barriers must be in place before the first erosion-causing storm following soil disturbance.
    - ***Rationale:*** *Construction areas create the most potential for erosion and sedimentation and should be undertaken at the appropriate times of year to miss the moisture producing months. This will reduce the amount of sedimentation production and erosion occurrences.*

Recreation – Forest Wide

Trails – Forest Wide

- Obliterate user-constructed trails whose continued use would damage or threaten aquatic resources.
    - ***Rationale:*** *The most potentially sediment producers are roads and trails. Anytime a trail is generating undesired results to resources it should be rerouted to a more favorable site or closed completely.*
- Divert water runoff from trails to reduce erosion. Provide drainage either by rolling the trail grade, outsloping the tread, or establishing cross drains.
    - ***Rationale:*** *This action reduces the amount of sediment reaching the stream.*
- Minimize the number of stream crossings. To reduce erosion, harden crossings or use bridges on larger streams.
    - ***Rationale:*** *The less number of crossings the less potential production of sedimentation and the hardening of approaches and use of bridges on larger streams reduce the amount of erosion and sedimentation production.*
- Design trails on sideslopes of less than a 40-percent grade and avoid sensitive soil types whenever possible.
    - ***Rationale:*** *This minimizes erosion and production of sediment. Trails on steep slopes also are susceptible to erosion from runoff, especially when users make "shortcut" trails between switchbacks.*

- Design turns to minimize excavation and cutbank exposure. This may be accomplished by using climbing turns and avoiding switchbacks whenever possible.
    - ***Rationale:*** *This minimizes erosion and production of sediment.*
- Hardening of climbing turns, switchbacks, and stream approaches is recommended.
    - ***Rationale:*** *This minimizes erosion and production of sediment.*
- Locate stream crossings in areas that have as many of the following features as possible.
        - A well-defined stream channel
        - Minimal channel width
        - A flat stream gradient
        - Stable approaches on both sides of the crossing
    - ***Rationale:*** *This minimizes erosion and production of sediment.*
- Restrict traffic on trails to meet trail management objectives and minimize resource damage. This may include seasonal closures.
    - ***Rationale:*** *This minimizes potential erosion and production of sediment.*
- Horse-trail and OHV stream crossings and approaches will be hardened.
    - ***Rationale:*** *This minimizes potential erosion and production of sediment.*
- Avoid locating stream crossings in areas with Protected, Endangered, Threatened, and Sensitive (PETS) species.
    - ***Rationale:*** *This will minimize the potential for affecting the species present.*

Dispersed Recreation – Forest Wide

- Camping in dispersed recreation areas is not allowed within 30 m (100 feet) of perennial streams or lakes.
    - ***Rationale:*** *This action reduces the potential of erosion of stream banks and the production of unwanted sedimentation.*
- Areas having aquatic resource damage, erosion, or excess vegetative damage because of overuse will either be hardened or closed and rehabilitated.

    - ***Rationale:*** *Any activity or structure creating unwanted sediment and/or erosion needs to be restored or moved to another less damaging site.*

- Tethering or corralling of horses or other livestock is not allowed within 30 m (100 feet) of perennial streams or lakes.

    - ***Rationale:*** *The tethering or corralling of horses or other livestock outside of 30 m (100 feet) of perennial streams or lakes will enhance the production of bare stream banks or conduits for sedimentation directly into the stream. It will also negate the potential of damaging or killing of the vegetation on the streambanks lessening their ability of stabilizing the streambank.*

Fish, Wildlife, and Range Management – Forest Wide

- Wildlife ponds (including constructed wetlands) within the RMA are generally discouraged, but may be approved on a site-by-site basis. The DBNF hydrologist and fisheries biologist must be involved in such projects.

    - ***Rationale:*** *Any soil disturbance has the potential to add unwanted sediment loads into the neighboring water body. Each project should be judged as to its appropriateness' individually.*

- Generally, impoundments are prohibited, although they may be approved on a site-by-site basis.

    - ***Rationale:*** *Impoundments have been stated as one of the major causes for mussel decline over the last century. Generally, impoundments are detrimental for native fauna while at the same time providing habitat for desired recreational species.*

- Woody debris naturally occurring in streams will be removed only when it has demonstrably degraded habitat for riparian-dependent species, or when it poses a direct threat to private property or DBNF infrastructures, e.g., bridges. The need for removal must be determined on a case-by-case basis following consultation with the Forest Hydrologist and Fisheries Biologist.

    - ***Rationale:*** *CWD is a major component of the River Continuum Theory (Vannote 1980) and is the root of the aquatic life. It also provides for various needed habitats for various aquatic species.*

- Stream structures may be used to enhance habitat for trout or native aquatic species. Structures will be designed to mimic the appearance and function of natural habitat features. Heavy equipment use in streams is permitted but should be kept to a minimum and supervised by the Forest Hydrologist and Fisheries Biologist. Approved permits must be obtained.

    - ***Rationale:*** *This will allow for the construction of needed habitat that has either been destroyed or damaged to the extent that it is uninhabitable. Some species* *such as some of the fish hosts for mussels need these type structures for their life histories.*

- From February through July, which is the spawning period or juvenile rearing time for most rare and other aquatic species, the DBNF Fisheries Biologist and /or State Biologists must be consulted before instream disturbance activities are approved.
    - ***Rationale:*** *This ensures that an important species will not be disturbed during an important time of its life history and ultimately its viability on the Forest.*
- Fish stocking may be permitted as long as populations of native aquatic species are maintained or enhanced.
    - ***Rationale:*** *The potential impact of any non-indigenous species on the native aquatic fauna will be evaluated by the Forest Fisheries Biologist. Fish stocking will be coordinated through a Memorandum of Understanding among State, the Forest Service, and other interested groups.*

Range – Forest Wide

- Perennial and intermittent streams channels will be fenced to exclude animals. Crossings and other access sites will be hardened.
    - ***Rationale:*** *Domestic farm animals (including horses) can be some of the most damaging "vehicles" to a stream channel. When trodden down and forded numerous times the stream banks start to erode and unwanted sediment enters the stream. Allowing for limited access to hardened crossings and the construction of drinking facilities elsewhere will minimize this process as well.*
- Feeding troughs, watering troughs, and salt and mineral blocks will be placed outside of the RMA and SMZ's.
    - ***Rationale:*** *This will minimize the amount of erosion and sedimentation production.*

Minerals - Forest Wide

Federally controlled minerals

- Surface occupancy is prohibited within the Riparian Management Area.
    - ***Rationale:*** *Mineral extraction activities can adversely affect water quality, aquatic habitats, species richness, and the diversity of aquatic flora and fauna communities and my cause fragmentation of aquatic communities. Erosion and sedimentation, acid mine drainage, release of brine wastewater, and oil spills are leading causes of problems associated with mining and mineral extraction.*

- Where mineral mining operations are conducted adjacent to seeps, springs, and karst features (sink holes) found outside the RMA, implement prescribed mitigation measures.

    - Coal –

    - Oil and Gas-

  A permitted operation may be temporarily suspended due to wet weather when unacceptable resource damage is anticipated or may be occurring.

  - ***Rationale:*** *Erosion and sedimentation loading can potentially be greatly increased when ground disturbance takes place in the "wet seasons".*

    - All mud pits, disposal pits, and auxiliary pits will be lined with an appropriate, impermeable liner. All drilling fluids and cuttings must be captured in a pit and removed from the DBNF as soon as possible and taken to an approved disposal site.

      - ***Rationale:*** *This process will minimize the potential of spillage or leakage into water bodies.*

    - To ensure that pollutants are contained on a site, drainage on the drill pad will be contained behind a berm constructed around the pad's perimeter.

      - ***Rationale:*** *This process will minimize the potential of spillage or leakage into water bodies.*

    - Any brine resulting from the operation will be transported for disposal away from National Forest lands.

      - ***Rationale:*** *This process will minimize the potential of spillage or leakage into water bodies.*

    - Transportation system roads with adequate drainage structures and rock surfacing will be maintained to their standard and not allowed to deteriorate. Erosion problems resulting from poorly drained and inadequately surfaced roads will be remedied by upgrading those roads, e.g., eliminating erosion, gullying, and stream sedimentation.

      - ***Rationale:*** *Roads account for 90 percent of the sediment resulting from forestry activities (Eschner and Larmoyeux, 1963; Douglass and Swank, 1975; Ursic and Douglass, 1978; Yoho, 1980; Golden and other, 1984; Swift, 1985, 1993).*

    - Oil storage tanks shall be enclosed by a berm large enough to contain one and one-half times the capacity of the largest tank in the tank battery. All valves leading from oil storage tanks will be locked. Berms will have a clay core or other, similarly impermeable material. The berm's top will be level and maintained at the elevation at which it was constructed.

- ***Rationale:*** *This process will minimize the potential of spillage or leakage into water bodies.*

- Any liquids collected within a berm, including liquids that may be rainwater, will not be drained off the site. Drains will not be installed. Liquids will be removed by vacuum truck to an approved disposal or injection facility. A representative from the DBNF may approve the siphoning-off of rainwater if the facility has no history of saltwater contamination, or if the water has been tested and found free of contaminants.

  - ***Rationale:*** *This process will minimize the potential of spillage or leakage into water bodies.*

- After production operations have been completed, tank batteries, flow lines, and related facilities will be removed. The disturbed area will be reclaimed to prevent erosion and stream sedimentation. It will then be re-shaped to produce a smooth, uniform slope with all holes and depressions filled. Where the DBNF representative deems it necessary, the area shall be scarified (ripped) to provide a good seedbed prior to liming, fertilizing, seeding (preferably with native plant materials) and mulching.

  - ***Rationale:*** *This procedure will minimize erosion and stream sedimentation.*

- Common Variety Materials (Salable) – Sale or removal of mineral materials from stream channels or RMA's, such as sand and gravel, is prohibited. Such activities are not compatible with the Desired Condition for riparian or aquatic habitats.

  - ***Rationale:*** *Ground/substrate disturbance generates erosion and sedimentation which can be detrimental to the various life histories of most of the aquatic species. It will also degrade if not destroy needed habitat for these species.*

IV. Management Needs: Monitoring and Inventory to Ensure Species Viability

Restoration and Recovery of Threatened or Endangered Species

The purpose of a recovery plan for threatened or endangered species is to "…delineate reasonable actions which are believed to be required to recover and/or protect the species" (USFWS, 1989). Over half of the action strategies thought to be necessary for restoration and recovery of aquatic species on the DBNF are very general and vague. For some species, life histories and/or life cycles are well described, but for many others virtually nothing is known. Most species found on the DBNF are the latter. Viable key actions, which can be implemented today, include:

(1) acquire land known to be occupied by such species,

(2) restore riparian and aquatic habitats that are critical to life histories, and

(3) ensure that BMP's are followed when conducting any activities that may affect aquatic resources.

In addition, surveys of current populations and of habitats suitable for species restoration must be continued and expanded. As required by federal mandates, i.e., the Endangered Species Act, highest priority should be given those fish and mussel species identified in Tables 3 and 5 as federally endangered or threatened. Other species with conservation status should also be given high priority for restoration of populations and habitat. These species are the pool from which federal listings are often drawn; conservation actions by the DBNF may help prevent future listings. Most of these would benefit Forest Service acquisition and management of the habitats in which they are found. Although some of the fish species may benefit from the creation or modification of habitat, e.g., deep pools, root wads, and CWD, for mussels there is insufficient information about basic life history and distribution to recommend habitat improvement procedures.

Inventory of Fauna and Habitat Conditions - (High Priority)

Inventory is essential for establishing baseline data on the biotic and abiotic components of aquatic systems; and it is therefore a critical step in the monitoring process. Habitats in all streams on the DBNF should be inventoried to assess current conditions. Reliable inventory techniques should be used to collect baseline data on appropriate physical, chemical, and biological parameters.

Water quality —Inventory protocols should follow standard Forest Service methods.

Sediment transport—Inventory protocols should follow Dissmeyer 1994.

Stream inventory—The basic principles of Basinwide Visual Estimation Techniques (BVET) (Hankin and Reeves, 1988) should be followed for all stream habitat and fish population inventory and monitoring. Specifically, sample sites should be selected from naturally occurring habitat, e.g., pools, riffles, according to a random-systematic design (Dolloff and others, 1993). Ultimately, complete basinwide surveys should be conducted on all DBNF streams. These surveys should collect baseline data and be used to support project-level analyses and monitoring.

Habitat and aquatic biota components should be selected to address clearly defined objectives such as guidelines identified in the revised Forest land Resource Management Plan. Habitat inventories should include variables such as: habitat type, (pool, riffle), length, width, area, maximum depth, average depth, residual volume (pools only), dominant substrate, and CWD loading. Pieces or volume of CWD should be counted or measured. The location of wood can be mapped through the use of hip-chain or a global positioning system (GPS), or provided by linear density (pieces/mile). Pool-riffle ratio should be calculated from the habitat-area data collected during the BVET. Because the cost of stream surveys must be considered, stream inventory and monitoring should be based on clearly defined needs and priorities. A hierarchical approach should be used to determine sampling strategy and intensity. A hierarchical strategy for inventorying and monitoring streams on the DBNF is given in Appendix 3.

Protocols for freshwater mussel population inventories are being developed by Warren and Haag of the USDA Forest Service Southern Research Station. As they become available, these methods should be adopted to inventory mussels on the DBNF.

Monitoring and Evaluation

Introduction

With passage of the NFMA, Congress required the Forest Service to monitor the effects of all its activities. Monitoring provides direct information about 1) how well the desired resource objectives identified in the planning process were met during project implementation, 2) whether necessary resource protection measures were applied, and 3) how effective these measures were.

Monitoring of Operational Standards and Guidelines

This section addresses implementation and effectiveness monitoring of the Standards and Guidelines outlined in the Aquatic Conservation Assessment (ACA). Both physical and biological attributes of aquatic systems are addressed. Most of the information was compiled from various published and unpublished documents that are currently used on the DBNF and in other Region 8 national forests, as well as the Center for Aquatic Technology Transfer (CATT).

Implementation Monitoring (High Priority)

Purpose: Implementation monitoring will focus on determining whether the Standards and Guidelines and BMP’s outlined in the DBNF Aquatic Conservation Strategy are employed during on-the-ground management activities.

Methods: Implementation monitoring will follow procedures established for the DBNF. Before beginning any on-the-ground activity, project managers will prepare a checklist developed from forest-wide and project-specific standards and guidelines and BMP's and the Aquatic Conservation Strategy. Project reviewers will visit each site and mark a "yes" or "no" for each attribute on the list and will sign and date each list. The lists will be filed both in the Ranger District project file and at the Forest Supervisors Office. Other documents to be filed with the monitoring checklist will include contract officer/inspector daily diaries, photographs, and specialists' field review reports.

Frequency of monitoring: Monitoring to verify the use of best management practices will begin at the start of all activities and continue until activities cease. The consistency of implementation monitoring will be reviewed on a minimum of two new management activities per ranger district each fiscal year. The projects that are selected will represent a sample of timber harvest, road construction/reconstruction, recreation development, wildlife/fisheries habitat improvement, and other projects that are undertaken by the ranger districts. Staff from the DBNF, ranger district personnel, and line officers jointly will select the projects and sites for review.

Data analysis: Compliance or non-compliance with Standards and Guidelines and BMP's will be determined by tallying the number of "yes" responses on completed checklists. A minimum of 90 percent "yes" checkmarks will indicate satisfactory implementation of resource protection measures.

Responsible person(s) and reporting requirements: Soil and water staff resource specialists from the DBNF Supervisor's Office, ranger district resource specialists, timber sale administrators, engineering contract inspectors, and other personnel will be responsible for on-site field inspections of the individual management activities. The ranger district aquatic resource specialist will maintain a copy of implementation monitoring records, and the Supervisors Office soil and water staff will maintain the DBNF file. Some implementation reviews may involve interdisciplinary field visits associated with specific projects.

Effectiveness monitoring (High Priority)

Purpose: Determine if BMP's, Standards and Guidelines, and other resource protection measures are effective in meeting the Desired Future Condition.

Methods: Standard methods and procedures will be used to assess changes in soil and water movement, water quality, and aquatic biota. Sampling methods will include (but nort be limited to): channel cross-sections, physical and chemical analyses, basin-wide habitat and fish population surveys (BVET) methods, mussel monitoring methods, and random surveys of aquatic biota. Monitoring sites will be associated with ongoing and completed activities. Baseline (pre-project implementation) monitoring data will be collected for all proposed activities.

Frequency of monitoring: Monitoring of affected resources will occur at selected sites or watersheds during intervals established in the DBNF Annual Monitoring Plan. All activities with the potential to increase the transport of sediment to water-bodies also will be monitored during or following storm (bankfull) events.

Data analysis and interpretation: Qualitative and quantitative methods both will be used to analyze collected data. The data will be compared with established Desired Conditions and displayed in figures for qualitative analysis and interpretation. Depending on monitoring objectives, study design, and sample size, either parametric or non-parametric statistical methods may be applied to help determine the effectiveness of resource protection measures.

Responsible persons/reporting requirements: As identified in the DBNF Annual Monitoring Plan, staff from the ranger districts and the forest supervisors office will be responsible. Ranger district personnel will retain the data, although both offices will contribute to data analysis and preparation of the annual monitoring report. A copy of the report will be kept at the ranger station and with the Supervisors Office aquatic resource staff.

Aquatic Biota Inventory protocol. (Medium Priority)

All streams on the DBNF should be inventoried to assess how closely current conditions approximate desired conditions. Reliable inventory techniques should be used to collect baseline data on appropriate physical, chemical, and biological parameters. Because the cost of stream surveys must be considered, stream inventory and monitoring should be based on clearly defined needs and priorities

Water quality - inventory protocols should follow standard Forest Service methods.

Sediment transport - inventory protocols should follow Dissmeyer, 1994.

Stream inventory - Follow established inventory protocols such as Basinwide Visual Estimation Techniques (BVET; Hankin and Reeves 1988) for all stream habitat and fish population inventory and monitoring. Specific sample sites should be selected from naturally occurring habitat (e.g. pools, riffles) within stream reaches according to a random-systematic design (see Dolloff et al. 1993).

Ultimately, complete surveys should be conducted on all DBNF streams. These surveys should consist of baseline data and be used to support project level analyses and monitoring. Habitat and aquatic biota components should be selected to address clearly defined objectives such as guidelines identified in the revised forest plan. Habitat inventories should include variables such as: habitat type (e.g. pool, riffle), length, width, area, maximum depth, average depth, residual pool volume (pools only), dominant substrate, and coarse woody debris loading. Reference reaches may be inventoried to serve as samples in monitoring aquatic habitat trends.

Coarse woody debris should be counted. The location of wood can be identified by hip-chain or global positioning system (GPS). Pool-riffle ratio should be calculated from the habitat-area data collected during the inventory. Protocols for freshwater mussel population inventories are currently being developed by Warren and Haag of the USDA Forest Service Southern Research Station. These methods should be adopted to inventory mussels on the DBNF as they become available.

Fish biodiversity - Historical fish distributions should be collected from appropriate sources and compiled in a geographical information systems (GIS) compatible format. Fish distribution records should be reviewed before conducting new fish inventories to identify streams and sites likely to contain species of conservation interest.

For larger streams, select 1 to 2 % of the pool-riffle combinations within the stream (i.e. one out of 20 pool- riffle combinations for a 5 % sample) for one pass electrofishing surveys. Plot cumulative number of species captured *(y* - axis) by cumulative pool-riffle combination area *(x* - axis) to determine if the sample size is adequate for a cursory estimate of the total fish community. The sample size should be acceptable when the curve through the data reaches a stable asymptote (e.g. about five habitat-units sampled with no previous unsampled species in the catch). When appropriate, seining techniques, following the protocol of Jenkins and Burkhead (1994) should replace electrofishing in streams suspected of containing threatened or endangered species.

More intensive sampling (see below) should be employed when negative changes in the fish community are detected or when species of conservation interest appear to be absent from a stream or stream section in which they historically occurred.

Fish inventory - A hierarchical approach should be used to determine sampling strategy and intensity. Below is an example outline of a hierarchical strategy for inventorying and monitoring streams on the DBNF.

Watersheds Not Containing Species Of Conservation Interest – (Lower Priority)

Systematically select 1 to 2 % of the pool-riffle combinations within the stream (i.e. one out of 20 pool- riffle combinations for a 5 % sample). Collect measurements of the minimum habitat characteristics (see above) and locate sample-sites by hip-chain measurement and physical landmarks or GPS. In each selected unit use one-pass electrofishing to survey the fish community.

Plot cumulative number of species captured *(y* - axis) by cumulative pool-riffle combination area *(x*- axis) to determine if the sample size is adequate for an acceptable estimate of the total fish community. The sample size should be acceptable when the curve through the data reaches a stable asymptote (e.g. about five habitat-units sampled with no previous unsampled species in the catch).

Watersheds that do not contain Species Of Conservation Interest But Receive High

Recreational Use Or Where Management Activities Are Planned – (Lower Priority)

Recommended effort

Complete habitat survey following the protocol of Dolloff et al. (1993). Collect measurements of the minimum habitat characteristics (see above) and locate sample-sites by hip-chain measurement and physical landmarks or GPS.

Conduct three-pass electrofishing removal techniques to inventory fish populations in 20 random-systematically selected pool-riffle combinations. Summarize population data to be sure population estimates are within two standard deviations of the mean; if not, increase the sample size. Plot cumulative number of species captured *(y* - axis) by cumulative pool-riffle combination area *(x* - axis) to determine if the sample size is adequate for an acceptable estimate of species richness. The sample size should be acceptable when the curve through the data reaches a stable asymptote (e.g. about five habitat-units sampled with no previous unsampled species in the catch).

Minimum effort

From a random starting point in the target stream, systematically select 10 pool-riffle combinations. Locate sample-sites by hip-chain measurement and physical landmarks or GPS. In each selected unit, record the minimum habitat characteristics (see above). Summarize habitat data to be sure observations are within two standard deviations of the mean for each variable; if not, increase the sample size. In each selected unit use one-pass electrofishing to survey species richness. Plot cumulative number of species captured *(y* -axis) by cumulative pool-riffle combination area *(x*- axis) to determine if the sample size is adequate for an acceptable estimate of the total fish community. The sample size should be acceptable when the curve through the data reaches a stable asymptote (e.g. about five habitat-units sampled with no previous unsampled species in the catch).

Watersheds Containing Species Of Conservation Interest – (Medium Priority)

From a random starting point in the target stream, systematically select 50 of each habitat type. In each selected unit record the minimum habitat characteristics (see above), plus additional habitat characteristic specific to the target species, and count fish by underwater observations. Locate sample sites by hip-chain measurement and physical landmarks or GPS. Summarize habitat data to be sure observations are within two standard deviations of the mean for each variable; if not, increase the sample size.

Use underwater observation to assess the risk of electrofishing on the target species population before the technique is employed (see Leftwich et al., in review). Limit the use of electrofishing to minimize injurious effects on the target species populations.

Systematically select 10 of each habitat type from the units characterized for habitat (i.e. 10 of the 50 pools and 10 of the 50 riffles selected for underwater observation) for three-pass removal electrofishing.

Watersheds Containing Species Of Conservation Interest That Receive High Recreational Use Or Where Management Activities Are Planned Recommended effort – (High Priority)

Complete habitat and fish-population inventory and data analysis, following the protocol BVET of Dolloff et al. (1993), prior to management activity. The minimum habitat characteristics (see above) should be recorded, plus additional habitat characteristic specific to the target species. Fish population inventory, as outlined by Dolloff et al. (1993), may need to be modified to effectively sample target species while minimizing impact on their populations (see Leftwich et al., in review).

Minimum effort

From a random starting point in the target stream, systematically select 50 units of each habitat type. In each selected unit record relevant habitat characteristics and count fish by underwater observations. Locate sample-sites by hip-chain measurement and physical landmarks or geographic positioning system (GPS). Summarize habitat data to ensure observations are within two standard deviations of the mean for each variable; if not, increase the sample size. Systematically select 10 of each habitat type (e.g. 10 of the 50 pools and 10 of the 50 riffles selected for underwater observation) for three-pass removal electrofishing. Use underwater observations to assess the risk of electrofishing on the target species population before the technique is employed (see Leftwich et al., in review).

Aquatic Biota and T/E/S Species Monitoring Protocol

Aquatic habitat and fish population monitoring

Habitat monitoring should be conducted on each inventoried stream every 5 years or following management activities in the watershed or natural (e.g. floods, tornados, etc.) and human-caused (e.g. road failures) events. Monitoring protocols should be compatible with the inventory protocol. A hierarchical approach to monitoring should be used to determine sampling strategy and intensity. Below is an outline of a hierarchical strategy for monitoring streams on the DBNF. Data collected during monitoring should be compared with the respective inventory to evaluate changes in fish populations. When negative changes are detected in a stream, the stream should be resurveyed using the appropriate inventory protocol.

1). Watersheds Not Containing Species Of Conservation Interest

Systematically select 5 pool-riffle combinations within the stream.

Collect measurements of minimum habitat characteristics (see Appendix 3) and locate sample-sites by hip-chain measurement and physical landmarks or GPS.

In each selected unit use one-pass electrofishing to survey the fish community.

Plot cumulative number of species captured (y - axis) by cumulative pool-riffle combination area (x- axis) to determine if the sample size is adequate for an acceptable estimate of species richness. The sample size should be acceptable when the curve through the data reaches a stable asymptote (e.g. about five pool-riffle combinations sampled with no previous unsampled species in the catch).

Sampling Schedule

Monitoring should be conducted once every 5 years during periods of low flow.

Repeat survey following management activities within the watershed and following damaging natural (i.e. floods, tornados) and human-caused (i.e. chemical spills, road failures) events.

2). Watersheds Not Containing Species Of Conservation Interest But Receive High

Recreational Use Or Where Management Activities Are Planned

Systematically select 5 pool-riffle combinations within the stream.

Collect measurements of the minimum habitat characteristics and locate sample-sites by hip-chain measurement and physical landmarks or GPS. In each selected unit use one-pass electrofishing to survey the fish community. Plot cumulative number of species captured (y - axis) by cumulative pool-riffle combination area (x- axis) to determine if the sample size is adequate for an acceptable estimate of species richness. The sample size should be acceptable when the curve through the data reaches a stable asymptote (e.g. about five pool-riffle combinations sampled with no previous unsampled species in the catch).

Sampling Schedule

Monitoring should be conducted once every 3 years during periods of low flow.

Repeat survey following management activities within the watershed and following damaging natural (i.e. floods, tornados) and human-caused (i.e. chemical spills, road failures) events.

3). Watersheds Containing Species Of Conservation Interest

Systematically select 10 pool-riffle combinations within the stream. Collect measurements of the minimum habitat characteristics plus habitat characteristics specific to the target species and locate sample-sites by hip-chain measurement and physical landmarks or GPS. Summarize habitat data and compare to previous basinwide inventory. Estimates should fall within two standard deviations of the mean basinwide estimates for each variable; if not, increase the sample size. If estimates still exceed two standard deviations, repeat basinwide sampling at comparable flow. Where applicable, use underwater observations to assess relative abundance of target species (see Leftwich et al. in review). Electrofishing surveys maybe necessary when turbid stream conditions prevent reliable underwater observations or when objectives require precise estimates of population size with known confidence intervals. Electrofishing surveys should be designed to minimize injurious effects on the target species populations.

Species Richness

Plot cumulative number of species captured or observed (y - axis) by cumulative pool-riffle combination area (x - axis) to determine if the sample size is adequate for an acceptable estimate of species richness. The sample size should be acceptable when the curve through the data reaches a stable asymptote (e.g. about five habitat-units sampled with no previous unsampled species in the catch).

Sampling Schedule

Monitoring should coincide with the life cycle of the target species (e.g. once every three years for blackside dace) or following damaging natural (i.e. floods, tornados) and human-caused (i.e. chemical spills, road failures) events. Monitoring should be conducted during periods of low flow following the spawning season of the target species.

Repeat survey following management activities within the watershed.

4. Watersheds Containing Species Of Conservation Interest That Receive High Recreational Use Or Where Management Activities Have Been Implemented

Systematically select 20 pool-riffle combinations within the stream. Collect measurements of the minimum habitat characteristics plus habitat characteristics specific to the target species and locate sample sites by hip-chain measurement and physical landmarks or GPS. Summarize habitat data and compare to previous basinwide inventory. Estimates should fall within two standard deviations of the mean basinwide estimates for each variable; if not, increase the sample size. If estimates still exceed two standard deviations, repeat basinwide sampling at comparable flow. Where applicable, use underwater observations to assess relative abundance of target species (see

Leftwich et al. In review). Electrofishing surveys maybe necessary when turbid stream conditions prevent reliable underwater observations or when objectives require precise estimates of population size with known confidence intervals. Electrofishing surveys should be designed to minimize injurious effects on the target species populations.

Species Richness

Plot cumulative number of species captured or observed (y - axis) by cumulative pool-riffle combination area (x - axis) to determine if the sample size is adequate for an acceptable estimate of species richness. The sample size should be acceptable when the curve through the data reaches a stable asymptote (e.g. about five habitat-units sampled with no previous unsampled species in the catch).

Sampling Schedule

Monitoring should coincide with the life cycle of the target species or following damaging natural and human-caused events. Monitoring should be conducted during periods of low flow following the spawning season of the target species.

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Attachment A.

Species List: Lotic Habitat Association

Class	**Common Name**
AMPHIBIAN	Eastern Hellbender/ *Cryptobranchus a. alleganiensis* Mudpuppy/ *Necturus maculosus*
CRUSTACIANS	Big South Fork Crayfish/ *Cambarus bouchardi* Amphipods (general) – includes Anamolus Spring Amphipod (*Crangonyx anomalus*); Packard’s Cave Amphipod (*Crangonyx packardi*); and Central Kentucky Cave Amphipod (*Stygobromus exilis*) Neglected Fairy Shrimp/ *Eubranchipus neglecta* Packard's Southern Crayfish/ *Orconectes australis packardi* Springtail Fairy Shrimp/ *Streptocephalus secti*
FISH	American Brook Lamprey/ *Lampetra appendix* Arrow Darter/ *Etheostoma sagitta* Arrow Darter/ *Etheostoma sagitta spilotum* Ashy Darter/ *Etheostoma cinereum* Banded Darter/ *Etheostoma zonale* Banded Sculpin/ *Cottus carolinae* Barcheek Darter/ *Etheostoma obeyense* Blackside Dace/ *Phoxinus cumberlandensis* Blotched Chub/ *Erimystax (Hybopsis) insignis* Blotchside Logperch/ *Percina burtoni* Bluebreast Darter/ *Etheostoma camurum* Bluegill/ *Lepomis macrochirus* Central Stoneroller/ *Campostoma anomalum* Channel Catfish/ *Ictalurus punctatus* Cumberland Johnny Darter/ *Etheostoma susanae (nigrum susanae)* Duskytail Darter *Etheostoma percnurum* Eastern Sand Darter/ *Ammocrypta pellucida* Fantail Darter/ *Etheostoma flabellare* Freshwater Drum/ *Aplodinotus grunniens* Gilt Darter/ *Percina evides* Green Sunfish/ *Lepomis cyanellus* Greenside Darter/ *Etheostoma blennioides* Johnny Darter/ *Etheostoma nigrum nigrum* Kentucky Snubnose Darter/ *Etheostoma rafinesquei* Lake Sturgeon/ *Acipenser fulvescens okasis* Largemouth Bass/ *Micropterus salmoides* Logperch/ *Percina caprodes* Longear Sunfish/ *Lepomis megalotis*

Class	**Common Name**
	Longhead Darter/ *Percina macrocephala*
	Mountain Brook Lamprey/ *Ichthyomyzon greeleyi*
	Muskellunge (Native Pop. only)/ *Esox masquinongy*
	Northern Brook Lamprey/ *Ichthyomyzon fossor*
	Northern Hogsucker/ *Hypentelium nigricans*
	Northern Madtom/ *Noturus stigmosus*
	Ohio Lamprey/ *Ichthyomyzon bdellium*
	Olive Darter/ *Percina squamata*
	Paddlefish/ *Polydon spathula*
	Palezone Shiner/ *Notropis albizonatus*
	Rainbow Darter/ *Etheostoma caeruleum*
	Redside Dace/ *Clinostomus elongatus*
	River Chub/ *Nocomis micropogon*
	Rock Bass*/ /Ambloplites rupestris*
	Sauger/ *Stizostedion canadense*
	Sawfin Shiner/ *Notropis sp.*
	Shorthead Redhorse/ *Moxostoma macrolepidotum*
	Smallmouth Bass*/ Micropterus dolomieui*
	Southern Cavefish/ *Typhlichthys subterraneus*
	Spotted Darter/ *Etheostoma maculatum*
	Striped Darter/ *Etheostoma virgatum*
	Striped Shiner/ *Luxilus (Notropis) chrysocephalus*
	Tippecanoe Darter/ *Etheostoma tippecanoe*
	Walleye (Native pop. only)/ *Stizostedion vitreum*
	Warmouth/ *Lepomis gulosus*
	Western sand darter/ *Ammocrypta clara*
	White Crappie/ *Pomoxis annularis*
	White Sucker/ *Catostomus commersoni*
	Whitetail Shiner/ *Cyprinella (Notropis) galactura*
	Yellow Perch/ *Perca flavescens*
GASTROPODA	Armored Rocksnail/ *Lithasia armigera*
	Domed Ancylid/ *Rhodacme elatior*
	Onyx Rocksnail/ *Leptoxis praerosa*
	Shortspire Hornsnail/ *Pleurocera curta*
INSECTA	Pygmy Snaketail/ *Ophiogomphus howei*
	Helma's net-spinning caddisfly/Cheumatopsyche helma
PELECEPODA	Appalachian Monkeyface/ *Quadrula sparsa*
	Catspaw/ *Epioblasma obliquata obliquata*
	Clubshell/ *Pleurobema clava*
	Cracking Pearlymussel/ *Hemistena lata*
	Cumberland Bean Pearlymussel/ *Villosa trabalis*
	Cumberland Papershell/ *Anodontoides denigratus*

Class	**Common Name**
	Cumberland, Elktoe/ *Alasmidonta atropurpurea*
	Cumberlandian Combshell/ *Epioblasma brevidens*
	Dromedary Pearlymussel/ *Dromus dromas*
	Elktoe/ *Alasmadonta marginata*
	Fanshell/ *Cyprogenia stegaria*
	Fluted Kidneyshell/ *Ptychobranchus subtentum*
	Green Floater/ *Lasmigona subviridus*
	Little Spectaclecase/ *Villosa lienosa*
	Little-wing Pearlymussel/ *Pegias fabula*
	Long-solid/ *Fusconaia subrotunda subrotunda*
	Northern Riffleshell/ *Epioblasma torulosa biloba (t. rangiana)*
	Orange-foot Pimpleback/ *Plethobasus cooperianus*
	Oyster Mussel/ *Epioblasma capsaeformis*
	Pink Mucket/ *Lampsilis abrupta*
	Pocketbook/ *Lampsilis ovata*
	Purple Lilliput Pearlymussel/ *Toxolasma lividus*
	Pyramid Pigtoe/ *Pleurobema rubrum (pyramidatum)*
	Rabbitsfoot/ *Quadrula cylindrica cylindrica*
	Ring Pink Mussel/ *Obovaria retusa*
	Rough Pigtoe/ *Pleurobema plenum*
	Round Hickorynut/ *Obovaria subrotunda*
	Salamander Mussel/ *Simpsonaias ambigua*
	Sheepnose/ *Plethobasus cyphyus*
	Snuffbox/ *Epioblasma triquetra*
	Spectacle Case/ *Cumberlandia monodonta*
	Tan Riffleshell/ *Epioblasma florentina walkeri*
	Tennessee Clubshell/ *Pleurobema oviforme*
	Tubercled-blossom Pearlymussel/ *Epioblasma torulosa torulosa*
	White Wartyback/ *Plethobasus cicatricosus*
	Yellow-blossom Pearlymussel/ *Epioblasma florentina florentina*

Attachment B.

Lotic Species/Habitat Relationships with References

AMPHIBIAN

Eastern Hellbender – *Cryptobranchus a. alleganiensis* – lives under large rocks and bedrock ledges in clean rivers and large streams (MacGregor, 1993).

Mudpuppy – *Necturus maculosus* – Found in all types of aquatic situations such as lakes, ponds, rivers, streams and other permanent bodies of water and in all conditions of water such as foul and warm to cool and high oxygen (Conant and Collins 1991).

CRUSTACEANS

Amphipods (general)

Generalized statements about the habitat needs of this group are: usually restricted to permanent bodies of water that are relatively cool, clean, and well oxygenated (Thorp 2001 p. 791). Three amphipods thought to be either on the Forest and found nearby are as follows:

Anamolus Spring Amphipod – *Crangonyx anomalus* – (spring)

Packard's Cave Amphipod – *Crangonyx packardi* – (cave)

Central Kentucky Cave Amphipod – *Stygobromus exilis* – (cave)

Springtail Fairy Shrimp – *Streptocephalus secti* – Low salinity water, fairly tolerant to medium low conc. of oxygen, capable of diapause, found in ditches, temporary ponds, wetlands (Thorp 2001).

Neglected Fairy Shrimp – *Eubranchipus neglecta* – Low salinity water, fairly tolerant to medium low conc. of oxygen, capable of diapause, found in ditches, temporary ponds, wetlands (Thorp 2001).

Big South Fork Crayfish – *Cambarus bourchardi* – Entire known range is in the Roaring Paunch Creek drainage (tributary of Big South Fork) in Kentucky and adjacent Tennessee (MacGregor, 1993). Found in moderate gradient creeks, having rubble and moderate current (NatureServe, 2001).

Packard's Southern Crayfish – *Orconectes australis packardi* – Restricted to caves and subterranean streams in portions of the Cumberland and Rockcastle River drainages (MacGregor, 1993). "Quiet pools of subterranean streams" (NatureServe, 2001)

FISH

Lake Sturgeon – *Acipenser fulvescens okasis* – The lake sturgeons preferred habitat is large lakes and rivers (Etnier and Starnes 1993). It feeds chiefly over a clean bottom of sand, gravel and rocks (Trautman 1981). It has also been reported over a substrate of cobble, pebble, gravel, and sand (Burr and Warren 1986).

Rock Bass – *Ambloplites rupestris* – This species can be found associated with sheltered pool areas in cold to warm creeks and rivers. They are occasionally associated with rocky shores in reservoirs. They are usually found in the cover of roots and brush (Etnier and Starnes 1993). Burr and Warren (1986) reports the rock bass in pools from clear upland streams and rivers with boulder, cobble, pebble, and gravel substrate, and associated with emergent vegetation or instream shelter.

Western Sand Darter – *Ammocrypta clara* – Inhabits medium to large streams where it occurs in sandy areas with moderate current (Etnier and Starnes 1993). It is also found from large streams to big rivers often associated with moderate current and a gravel and sand substrate (Burr and Warren 1986).

Eastern Sand Darter – *Ammocrypta pellucida* – The eastern sand darter inhabits sandy areas of small creeks to large rivers. It is most abundant in larger sandy areas of moderate to large streams with currents not strong enough to wash away the sand (Trautman 1981). It is also found frequenting the less turbulent, but clean swept margins of the main current over gravel and sand substrate (Burr and Warren 1986).

Freshwater Drum – *Aplodinotus grunniens* – The freshwater drum can be a common inhabitant of the backwaters and areas of sluggish current in large rivers and reservoirs. They are very tolerant of turbidity (Etnier and Starnes 1993) but appear to prefer clear waters and clean bottoms (Trautman 1981). Substrate preferences appear to be gravel, sand, mud, and organic debris (Burr and Warren 1986).

Central Stoneroller – *Campostoma anomalum* – The central stoneroller inhabits creek and stream reaches of moderate to high gradient that have permanent flow. It occupies riffles or flowing pools and raceways adjacent to riffles. Substrate preferences include bedrock, cobble, pebble, and gravel (Burr and Warren 1986). Spawning adults prefer clean gravel substrates (Etnier and Starnes 1993).

White Sucker – *Catostomus commersoni* – In the southeast the white sucker occurs in pool areas of tiny to moderate sized streams that are often intermittent. They are often associated with spring habitats and can occasionally be found in reservoirs. In the Midwest it is common in cool lakes. Spawning occurs over gravel areas in lakes and streams (Etnier and Starnes 1993). It is associated with substrates containing bedrock, cobble, gravel, and sand and cover in the form of emergent aquatic vegetation and instream shelter (Burr and Warren 1986).

Redside Dace – *Clinostomus elongates* – The redside dace inhabits very clear brooks and small streams with a moderate to high gradient. The preferred substrate is composed of clean gravel, sand, or bedrock, with organic debris present or absent. The pools have moderate flow and contain brush or roots and the banks are invariably shaded. It appears to prefer cooler water (Trautman 1981). Cobble and pebble has also been associated with preferred substrates (Burr and Warren 1986).

Banded Sculpin – *Cottus carolinae* – The banded sculpin is equally common from small springs to large upland rivers, and is frequently found in caves. It frequents riffle areas with gravel or rubble substrate. Small young can be found in quiet shallows and detritus strewn areas (Etnier and Starnes 1993). It can also be found over substrates of cobble, pebble, and gravel (Burr and Warren 1986).

Whitetail Shiner – *Cyprinella (Notropis) galactura* – This species inhabits clear upland creeks and rivers. It can be found in reservoirs but is most abundant in swift runs or flowing pools in clear streams, with coarse, firm substrates. Eggs are deposited beneath the bark of submerged logs, in bedrock crevices, or on the bottom or sides of rocks (Etnier and Starnes 1993). Typically found in pools with some current, especially with submerged logs, large boulders, and beds of water willow (Burr and Warren 1986).

Blotched Chub – *Erimystax (Hybopsis) insignis* – This species inhabits the riffle areas of moderate sized creeks to small rivers. Spawning areas are flowing pools devoid of vegetation, with a gravel, rock, and cobble substrate (Etnier and Starnes 1993). It occupies areas of continuous flow, clear water and cobble, gravel, pebble, and sand substrate. It is generally found in pools above and below riffles, and occasionally in the riffles, in water less than 1 m deep (Burr and Warren 1986).

Muskellunge (Native Pop. only) – *Esox masquinongy* – These fish inhabit relatively clear upland rivers where they occur in large rocky pools. They appear to prefer areas about 1 m. deep with plenty of fallen trees. Spawning habitat is believed to be shallow waters near the ends of pools areas. Movement during spawning is upstream and into smaller tributaries (Etnier and Starnes 1993). They are found over cobble, pebble, gravel, and sand substrate and in association with standing submerged timber, fallen logs with accumulated debris, or aquatic vegetation (Burr and Warren 1986).

Greenside Darter – *Etheostoma blennioides* – Adults typically occupy swift riffle areas with boulders or coarse rubble substrate in small to moderate rivers. They will often utilize deep pool areas during cooler months. Adults are often associated with attached aquatic vegetation. Juveniles can be found in shallow pool areas adjacent to riffles (Etnier and Starnes 1993). They can also be found over substrates of cobble, pebble, and gravel (Burr and Warren 1986).

Rainbow Darter – *Etheostoma caeruleum* – This species inhabits upland streams ranging from small creeks to medium sized rivers. Adults can be found in fast flowing riffles while younger individuals may be found near the margins or in runs or pools. They are most common in areas with fine gravel substrate (Etnier and Starnes 1993). Trautman (1981) found them to inhabit riffles 15 to 70 feet in width and an average depth of one foot over a substrate of sand, gravel and boulders. Burr and Warren (1986) associate rainbow darters with substrates containing cobble, pebble, and gravel.

Bluebreast Darter – *Etheostoma camurum* – Bluebreast darters can be found in moderate to large rivers in areas with moderate to swift current. They inhabit areas with coarse silt-free substrates of boulders, gravel, and bedrock in .5 to 1.5 meters of water (Etnier and Starnes 1993). Trautman (1981) reported that the streams needed to have unusually low amounts of turbidity. They can be found occupying the fast currents of shoal and riffles underlain with cobble, pebble, and gravel substrates (Burr and Warren 1986).

Ashy Darter – *Etheostoma cinereum* – This species can be found in small to medium rivers in association with bedrock or gravel substrate with boulders. It prefers water willow or other cover and minimal silt deposits. These areas are .5 to 2 meters in depth with sluggish currents (Etnier and Starnes 1993). They are most often found near shore to moderate current, above or below riffles or in pools and back eddies at a depth of 0.5 to 1.75 m. It prefers a substrate of mixed sand and gravel with some organic debris (Burr and Warren 1986).

Fantail Darter – *Etheostoma flabellare* – This species inhabits small to medium upland streams and less frequently in larger rivers. It can be found in rocky riffle areas with moderate to fast current in very shallow waters (Etnier and Starnes 1993). It may also be found in slow to moderate currents over substrates of mixed cobble, pebble, gravel, or sand. In larger rivers it occupies shallow marginal areas of flooded gravel bars with moderate current (Burr and Warren 1986).

Spotted Darter – *Etheostoma maculatum* – The spotted darter can be found in riffles with a rapid current flowing over a gravel and boulder strewn substrate (Trautman 1981). It primarily inhabits large streams and rivers in riffles and shoals with rapid flow and over a substrate of boulder, cobble, pebble, and gravel (Burr and Warren 1986).

Johnny Darter – *Etheostoma nigrum nigrum* – In the southern portion of its range the johnny darter chiefly inhabits sandy streams, northern populations will also occupy firm shoreline areas of lakes. Preferred habitats are moderately flowing runs with substrates of coarse sand (Etnier and Starnes 1993). The greatest population densities occur in small to medium sized streams of moderate gradient with a sandy gravel substrate (Trautman 1981). It is also frequently associated with sand, silt, or sand laden bedrock, but may also be found over mud. Spawning takes place in quiet, shallow pools under rocks, logs, and other objects (Burr and Warren 1986).

Barcheek Darter – *Etheostoma obeyense* – This species can be found in moderately flowing to sluggish pool areas of small to medium sized clear upland streams. In larger streams and rivers it is more abundant towards the headwaters. It inhabits streams relatively free of silt and prefers a substrate of slab rubble or small flat stones scattered over bedrock or sand and gravel. It can occasionally be found over sandy areas with detritus (Etnier and Starnes 1993). Other substrates associated with this species include cobble and pebble (Burr and Warren 1986).

Duskytail Darter – *Etheostoma percnurum* – Found in pools or raceways above riffles where abundant cobbles and slabrocks are available. Clutches of eggs laid on underside of slab rocks. (Burr and Eisenhour, Addendum 1998). “The duskytail inhabits the edges of gently flowing shallow pools, eddy areas, and slow runs in usually clear water of large creeks and moderately large rivers”…”very discriminatory about preferred microhabitat type, being found over heterogeneous mixtures of rock sizes from pea gravel, rubble/cobble, slab-rock, and boulder substrates” (Duskytail Darter Recovery Plan)

Kentucky Snubnose Darter – *Etheostoma rafinesquei* – Occupies upland creeks and streams primarily in rock bottom pools and pool margins, but during the fall and spring occurs in or at the margins of riffles in association with emergent vegetation (Burr and Warren 1986).

Arrow Darter – *Etheostoma sagitta* – The arrow darter inhabits smaller streams and occasionally can be found in medium to large rivers. Prefers a substrate of bedrock and rock rubble interspersed with sandy areas. It occurs in streams that are quite cool (21 C or less), with shade from dense riparian growth. It prefers sluggish to moderate current in rocky pool or run areas (Etnier and Starnes 1993). It can be found in sluggish pools above and below riffles over substrates of bedrock, cobble, and pebble (Burr and Warren 1986).

Arrow Darter – *Etheostoma sagitta spilotum* – The arrow darter inhabits smaller streams and occasionally can be found in medium to large rivers. Prefers a substrate of bedrock and rock rubble interspersed with sandy areas. It occurs in streams that are quite cool (21 C or less), with shade from dense riparian growth. It prefers sluggish to moderate current in rocky pool or run areas (Etnier and Starnes 1993). It can be found in sluggish pools above and below riffles over substrates of bedrock, cobble, and pebble (Burr and Warren 1986).

Cumberland Johnny Darter – *Etheostoma susanae (nigrum susanae)* – Upper short reaches of streams where there is shallow water in low velocity shoals and backwater areas of moderate to low gradient stream reaches with stable sand or sandy-gravel substrates (Status Review Cumberland Johnny Darter, 1999)

Tippecanoe Darter – *Etheostoma Tippecanoe* – This darter is only found in medium to large rivers. It occupies shallow riffle areas with substrates of fine, cherty gravel that approximately matches the background color of the males (Etnier and Starnes 1993). They have also been reported from areas of slow to moderate current and a bottom of clean gravel and sand (Trautman 1981). It can also be found in moderate to rapid currents of long, shallow pebble and gravel riffles (Burr and Warren 1986).

Striped Darter – *Etheostoma virgatum* – The striped darter favors small streams with areas of gentle currents adjacent to riffles, with a substrate of sand, gravel, and large rocks (Etnier and Starnes 1993). Primarily an inhabitant of the bases or margins of riffles and shallow pools over substrates of cobble, slab-shaped pebbles, gravel and sand (Burr and Warren 1986).

Banded Darter – *Etheostoma zonale* – This darter inhabits medium sized streams to rivers in gravel riffle areas. It reaches maximum abundance in riffles with lush growths of attached vegetation, particularly *Podostemum* (Etnier and Starnes 1993). It is often found in mid-channel riffles over substrates of cobble, pebble, and gravel (Burr and Warren 1986).

Northern Hogsucker – *Hypentelium nigricans* – The northern hogsucker prefers warmwater, riffles or adjacent areas, of moderate sized creeks and small rivers. It can be found in coldwater streams, tiny creeks, large rivers, and occasionally in reservoirs. It requires shallow gravel areas for spawning (Etnier and Starnes 1993). Preferred substrates include bedrock, cobble, pebble, gravel, and sand (Burr and Warren 1986).

Ohio Lamprey – *Ichthyomyzon bdellium* – Inhabits smaller upland rivers and infrequently reservoirs (Etnier and Starnes 1993). They need rather clear water with clean stream bottoms of sand, organic debris, and gravel. Spawning adults are found in sand and gravel bottomed riffles of moderate sized streams with moderate gradients. The young dig into bars containing a combination of sand, dark muck and organic debris (Trautman 1981). They are also found over substrates of cobble, pebble, gravel, sand, mud, and organic debris (Burr and Warren 1986).

Northern Brook Lamprey – *Ichthyomyzon fossor* – Spawning adults require small, clear, high gradient brooks having riffles with substrates of sand and gravel. The young require lower gradients having bottoms containing bars of mixed sand and organic debris (Trautman 1981). Burr and Warren (1986) report substrates of pebble, gravel, sand, mud, and organic debris with instream shelter.

Mountain Brook Lamprey – *Ichthyomyzon greeleyi* – This species inhabits small upland rivers and creeks. Spawning adults can be found in gentle riffles over gravel substrate with clear water at a depth of about 30 cm (Etnier and Starnes 1993). Spawning adults require small, clear, high gradient brooks having riffles with substrates of sand and gravel. The young require lower gradients having bottoms containing bars of mixed sand and organic debris (Trautman 1981). Preferred substrates may also contain pebble and mud (Burr and Warren 1986).

Channel Catfish – *Ictalurus punctatus* – Channel catfish are most typically inhabitants of medium to large warm rivers with alternating pool and riffle habitats. It spends daylight hours in quiet pools associated with cover and from dusk to dawn forages in both pool and swifter water. The channel catfish can also be found in reservoirs, natural lakes, farm ponds, and trout streams (Etnier and Starnes 1993). They can also be found in areas with fairly clean bottoms of sand, gravel, or boulders. When possible adults ascend small streams for the purpose of spawning. The yearlings and subadults appear more tolerant to fast current than adults (Trautman 1981). They are also found over substrates of gravel, sand, and mud (Burr and Warren 1986).

American Brook Lamprey – *Lampetra appendix* – The american brook lamprey can be found in upland creeks and small rivers usually with some gravel and sand substrate. Young inhabit sluggish current areas in silty detrital accumulations (Etnier and Starnes 1993). Spawning adults require small, clear, high gradient brooks having riffles with substrates of sand and gravel. The young require lower gradients having bottoms containing bars of mixed sand and organic debris (Trautman 1981). They can also be found over substrates containing pebbles and mud and in association with instream shelter (Burr and Warren 1986).

Green Sunfish – *Lepomis cyanellus* – The green sunfish can be found in small intermittent streams to ponds, lakes, and occasionally the margins of larger streams. Habitat characteristics for spawning include sunny areas near cover if possible (Etnier and Starnes 1993). This species principally inhabits streams of low to moderate gradient and displays no particular substrate preference. It is most abundant in sunken brush heaps and beds of aquatic vegetation (Trautman 1981). It can be found over substrates including cobble, pebble, gravel, sand, mud, and organic debris (Burr and Warren 1986).

Warmouth – *Lepomis gulosus* – The warmouth inhabits sluggish streams and lakes and is usually associated with areas of dense cover such as debris or weedbeds. Nest sites are constructed in areas of silty debris generally near cover (Etnier and Starnes 1993). It is also found in ponds, oxbows, marshes, and streams with silt free water. It prefers mucky bottoms that are covered with organic debris (Trautman 1981), but can be found over substrates containing gravel, sand, mud, and organic debris (Burr and Warren 1986).

Bluegill – *Lepomis macrochirus* – This species can be found in nearly all sizes of standing and moving water. It is most abundant in lakes and ponds and prefers shallow water with the cover of vegetation, woody debris, and/or rocks (Etnier and Starnes 1993). It typically occurs in clear, quiet waters where the bottom is of mixed cobble, pebble, gravel, sand, mud, and organic debris (Burr and Warren 1986).

Longear Sunfish – *Lepomis megalotis* – The longear sunfish is most common in moderately flowing streams where it occurs along the margins near cover such as vegetation, undercut banks, logs, or brush. It also occurs in a variety of habitats including reservoirs. Nests are often found along the gravelly margins of streams (Etnier and Starnes 1993). Preferred substrates include cobble, pebble, gravel, sand, mud, and organic debris (Burr and Warren 1986).

Striped Shiner – *Luxilus (Notropis) chrysocephalus* – The striped shiner occurs in sandy streams and pool areas of gravel bottom streams. It inhabits streams of all sizes but is most common in smaller creeks. Spawning occurs over unaltered gravel substrate in swift current, and over the nests of other cyprinids in swift to quiet waters (Etnier and Starnes 1993).

Smallmouth Bass – *Micropterus dolomieui* – The smallmouth bass can be found in clear upland creeks, rivers, lakes and reservoirs. It prefers areas with submerged logs, stumps and rock outcrops and some current if in a stream. In reservoirs, steep rocky slopes along submerged river and creek channels are preferred (Etnier and Starnes 1993). In lotic waters it is generally associated with clean pools with substrates of boulder, cobble, pebble, and gravel (Burr and Warren 1986).

Largemouth Bass – *Micropterus salmoides* – The largemouth bass inhabits sluggish waters in large streams, lakes and reservoirs. This species is more tolerant of turbidity than other members of the genus (Etnier and Starnes 1993). It is often found in association with vegetated littoral areas, standing timber, stumps and other cover. It can be found over substrates containing cobble, pebble, gravel, sand, mud, and organic debris (Burr and Warren 1986).

Shorthead Redhorse – *Moxostoma macrolepidotum* – This species typically occurs in large rivers over gravel to boulder substrate with swift water. Occasionally occurs in reservoirs, especially if the reservoir’s headwater rivers are large enough to provide suitable habitat. Spawning occurs over gravel shoals in water 15 to 21 cm deep (Etnier and Starnes 1993). It is also found in open pools and at the base of riffles or runs in medium to large streams and rivers with substrates of cobble, pebble, and gravel (Burr and Warren 1986).

River Chub – *Nocomis micropogon* – The favored habitat of the river chub includes large creeks to small rivers with rapid current, cool water, and rocky substrate (Etnier and Starnes 1993). Trautman (1981) reports river chubs from moderate to large streams with moderate to high gradient, and a substrate of gravel, boulders and bedrock. It is also found in clear pools with substrates of pebble, gravel, and sand (Burr and Warren 1986).

Palezone Shiner – *Notropis albizonatus* – Occurs in upland streams that have permanent flow, clean, clear water and pools with mixed cobble, pebble, gravel, and sand bottoms (Burr and Warren 1986).

Sawfin Shiner – *Notropis sp.* – Found in clear, cool, upland streams, occurring in pools with noticeable current or raceways over a rocky bottom (Burr and Warren 1986).

Northern Madtom – *Noturus stigmosus* – This species is characteristic of large streams and rivers where it frequents areas of moderate to swift current over a substrate of pebble, gravel, sand, and organic debris. It is sometimes found in association with pond weed (Burr and Warren 1986).

Yellow Perch – *Perca flavescens* – The yellow perch inhabits streams and lakes and prefers quiet waters often associated with rooted aquatic vegetation (Etnier and Starnes 1993). Found in greatest numbers in clear waters with a substrate of muck, organic debris, sand or gravel and an abundance of rooted aquatic vegetation (Trautman 1981).

Blotchside Logperch – *Percina burtoni* – Inhabits large creeks and small to medium rivers with low turbidity and moderate current. Seems to prefer areas of large gravel and cobble substrate, usually a half meter or more in depth (Etnier and Starnes 1993). Usually associated with clear streams harboring a diverse ichthyofauna (Burr and Warren 1986).

Logperch – *Percina caprodes* – This species occurs in large creeks and rivers, the lower reaches of small tributaries, and in reservoirs (Etnier and Starnes 1993). Typically found in moderate currents over substrates of pebble, gravel, sand, and organic debris (Burr and Warren 1986).

Gilt Darter – *Percina evides* – The gilt darter occupies upland rivers in shoal areas with moderate to fast current and a substrate of gravel, sand, and scattered rubble free of vegetation (Etnier and Starnes 1993). Trautman (1981) reported the gilt darter from the riffles and bars of moderate to large streams of moderate gradient with clean sand and gravel substrate. It is also found over substrates of cobble, pebble, and gravel (Burr and Warren 1986).

Longhead Darter – *Percina macrocephala* – The longhead darter predominantly occupies larger upland creeks and small to medium rivers of good quality, with little turbidity and negligible siltation. It occurs in pools with gentle current and a depth of about a meter with a clean sand-detritus or bedrock-boulder substrate. It prefers to be near the cover of brush, vegetation, or boulders (Etnier and Starnes 1993). It can also be found in deeper riffles of clear water with clean bottoms of gravel and boulders (Trautman 1981). Often associated with boulder and cobble strewn flowing pools and the areas above and below deep, fast riffles underlain with cobble and/or pebble (Burr and Warren 1986).

Olive Darter – *Percina squamata* – This species inhabits higher gradient upland rivers. There, it occupies boulder and bedrock chutes with moderate to torrential current (Etnier and Starnes 1993). It can also be found occupying main channels and deep, boulder, cobble, and pebble-strewn riffles (Burr and Warren 1986).

Blackside Dace – *Phoxinus cumberlandensis* – The blackside dace is found in small, upland creeks, 2 to 5 m wide. Typsically in sluggish pools, 0.3 to 1.0 m deep with a substrate containing bedrock, cobble, pebble, gravel, sand, and organic debris. It is often associated with undercut banks, brush, or slab rocks. The streams are shaded and cool (Burr and Warren 1986).

Paddlefish – *Polydon spathula* – The paddlefish inhabits large, silty rivers and reservoirs. Adults make upstream spawning runs, with spawning occurring in swift water over gravel bars and riprap areas. They also spawn in tailwater areas below dams (Etnier and Starnes 1993). They also spawn in backwaters and embayments of man-made impoundments. They need waters rich in zooplankton. Their preferred substrate is pebble, gravel, sand, and mud (Burr and Warren 1986).

White Crappie – *Pomoxis annularis* – The white crappie inhabits sluggish streams and lakes and is quite tolerant of turbidity. It prefers areas with plenty of cover such as brush and other obstructions. Nests are constructed near the cover of brush or overhanging banks in shallow protected areas such as coves or deeper overflow pools (Etnier and Starnes 1993). The white crappie is also found in large ponds and impoundments, over hard and soft bottoms, and areas containing aquatic vegetation, submerged brush, logs, stumps, and tree roots (Trautman 1981). It can also be found in rivers and large rivers over substrates of gravel, sand, mud, and organic debris often in association with emergent and aquatic bed vegetation, scrub-shrub, forested, and instream shelter (Burr and Warren 1986).

Sauger – *Stizostedion canadense* -- The sauger typically inhabits large, often turbid rivers and reservoirs. Spawning requires firm substrate, probably of rubble or gravel in tailwaters (Etnier and Starnes 1993). It occupies open water or deep pools with abundant bottom cover. In big rivers it occurs over firm cobble, pebble, gravel, and sand in areas of moderate to rapid current (Burr and Warren 1986).

Walleye (Native pop. only) – *Stizostedion vitreum* – Walleye can be found in larger rivers and clearer reservoirs. Most spawning occurs in rivers, when accessible, but also occurs in tailwaters, reefs or firm shorelines of lakes, and in flooded marshes. Spawning substrate varies from boulder and sand to flooded vegetation (Etnier and Starnes 1993). It can also be found in streams and rivers in the deep open waters of pools with abundant bottom cover. Substrate may also include cobble, pebble, gravel, and sand (Burr and Warren 1986).

Southern Cavefish – *Typhlichthys subterraneus* -- This species exists totally in subterranean environments (Etnier and Starnes 1993). Inhabits lentic cave waters over mixed gravel, sand, and mud substrates (Burr and Warren 1986).

GASTROPODA

Onyx Rocksnail – *Leptoxis praerosa* – The onyx rocksnail prefers medium to large rivers. It can be found on cobbles and boulders usually in or adjacent to current (USDA Forest Service 1994) It can also be found living on algae covered rocks in strong currents, mainly in large rivers (TABS 2000). “Found on algae-covered rocks in strong current” (NatureServe, 2001).

Armored Rocksnail -- *Lithasia armigera* -- This species inhabits algae covered rocks in riffle and shoal areas of large rivers (TABS 2000). Found “in partially buried logs, on gravel, and the species was found at its highest densities on submerged rock outcrops” (NatureServe, 2001).

Shortspire Hornsnail – *Pleurocera curta* –

Domed Ancy lid – *Rhodacme elatior* – Collected “from a stream 30 – 5- feet wide, 2 ½ to 4 feet deep, running over sand, mud, and gravel” (Branson and Batch, 1970).

INSECTS

Pygmy Snaketail – *Ophiogomphus howei* – No specific life history studies have been conducted on any of the species of *Ophiogomphus*. The nymphs may be extremely abundant in sandy substrates of streams, adults are seldom seen because of their secretive nature. Flights are often short, swift dashes over riffles from one resting spot to another (Brigham et al 1982).

Helma's Net-spinning Caddisfly – *Cheumatopsyche helma* - No specific life history studies have been conducted for this species. It is a benthic riverine species according to NatureServe (December 10, 2001).

PELECEPODA

Elktoe – *Alasmadonta marginata* – The elktoe prefers small, shallow rivers with a moderately fast current. Suitable substrate contains a mixture of fine gravel and sand (Parmalee and Bogan 1998) or in gravel or a mix of sand and gravel (Cummings and Mayer 1992).

Cumberland, Elktoe – *Alasmidonta atropurpurea* – This species can be found in one to two feet of water in slow moving streams. It appears to prefer a substrate of sand and mud with an abundance of coble (Parmalee and Bogan 1998).

Cumberland Papershell – *Anodontoides denigratus* – The Cumberland Papershell's habitat consists of "…cobbles and boulders in relatively shallow, low gradient pools and runs with little or no current and silt and sand substrates." (Cicerello/Marsh Ck) "Restricted to streams with sandstone bedrock" (NatureServe, 2001).

Spectacle Case – *Cumberlandia monodonta* – The spectacle case has been found in medium to large rivers with a variety of substrates. Substrates have included, gravel, sand and mud, fine mud between boulders adjacent to rapid currents, firm mud around eel grass roots adjacent to fast currents, and under large flat rocks in swift currents (Parmalee and Bogan 1998).

Fanshell – *Cyprogenia stegaria* – This species can be found, usually at depths less than three feet, in a substrate of course sand and gravel. Some have been found in firmly packed gravel in strongly flowing water in medium size rivers (Parmalee and Bogan 1998).

Dromedary Pearlymussel – *Dromus dromas* – This species prefers a gravel and sand substrate, possibly along shoals and riffles, in about three feet of water. It can be found in small to large rivers (Parmalee and Bogan 1998).

Cumberlandian Combshell – *Epioblasma brevidens* – The cumberlandian combshell has been reported from moderate sized streams to medium and large rivers. It has been associated with sand and gravel, and rocky substrates, in clear water about two feet deep (Parmalee and Bogan 1998).

Oyster Mussel – *Epioblasma capsaeformis* – This mussel can be found in shallow riffles in fast water less than three feet in depth in a gravel and sand substrate (Parmalee and Bogan 1998).

Yellow-blossom Pearly mussel – *Epioblasma florentina florentina* – This big river form of this species was probably found in riffles and shoals in sand and gravel substrate (Parmalee and Bogan 1998).

Tan Riffleshell – *Epioblasma florentina walkeri* – This species can be found in rivers with a substrate of coarse sand, gravel, and some silt. Usually found in areas of current in less than three feet of water (Parmalee and Bogan 1998).

Catspaw – *Epioblasma obliquata obliquata* – The catspaw is a medium to large river species, originally inhabiting riffles. It has been collected from swift water, 15 to 20 feet deep (Parmalee and Bogan 1998).

Northern Riffleshell – *Epioblasma torulosa biloba (r.rangiana)* – This species was found in riffle areas with swift currents in a substrate of coarse sand and gravel to firmly packed fine gravel, typically in shallow water (Parmalee and Bogan 1998).

Tubercled-blossom Pearlymussel – *Epioblasma torulosa torulosa* – This species was found in riffle areas with swift currents in a substrate of coarse sand and gravel to firmly packed fine gravel, typically in shallow water (Parmalee and Bogan 1998).

Snuffbox – *Epioblasma triquetra* – These mussels can be found in medium to large rivers in clear, gravel riffles (Cummings and Mayer 1992). They are often deeply buried in the gravel and sand substrate in areas of swift current (Parmalee and Bogan 1998).

Long-solid – *Fusconaia subrotunda subrotunda* – There are two forms of this species, the small to medium river form and the large river form. The first can be found in current, usually in riffle areas, at a depth of less than two feet. The second may live at depths of 12 to 18 feet, in current, and on a sand and gravel substrate (Parmalee and Bogan 1998).

Cracking Pearlymussel – *Hemistena lata* – This species is most numerous in medium-size rivers, deeply buried in a mud, sand, and fine gravel substrate. It usually occurs in less than two feet of water in moderate current (Parmalee and Bogan 1998).

Pink Mucket – *Lampsilis abrupta* – Pink muckets have been found in medium to large rivers in areas of swift currents and rocky bottoms, in less than three feet of water. They have also been found in riffles with strong currents (Parmalee and Bogan 1998). They are also known to inhabit substrates of sand and gravel (Cummings and Mayer 1992) or pure gravel to mud, with water depths of two to thirty feet (Harris and Gordon).

Pocketboo – *Lampsilis ovata* – This species is quite generalized in habitat preference. It can be found in small streams in less than two feet of water to large reservoirs at depths of 15 to 20 feet. It appears to do best in moderate to strong current in a substrate mixture of gravel and coarse sand mixed with some silt or mud (Parmalee and Bogan 1998). It can be found in habitats from silt to cobble, boulder and bedrock in 1 inch to 12 feet of water in standing to swiftly flowing current (Williams and Schuster 1989).

Green Floater – *Lasmigona subviridus* – This mussel prefers river pools and eddies with gravel and sand substrate. It has been found in areas of sand and gravel among boulders (Parmalee and Bogan 1998).

Ring Pink Mussel – *Obovaria retusa* – This mussel can be found in large rivers inhabiting gravel bars. It has been found in gravel and sand substrate in about two feet of water (Parmalee and Bogan 1998).

Round Hickorynut – *Obovaria subrotunda* – This mussel can be found in medium to large rivers with sand and gravel substrates with moderate flow, usually at depths less than six feet (Parmalee and Bogan 1998).

Little-wing Pearlymussel – *Pegias fibula* – This very small mussel can be found in cool, clear, high gradient streams. It is usually found in sand and fine gravel between cobbles in about 6 to 10 inches of water, often at the head of riffles (Parmalee and Bogan 1998).

White Wartyback – *Plethobasus cicatricosus* – This species inhabited shoals and riffles in large rivers (Parmalee and Bogan 1998).

Orange-foot Pimpleback – *Plethobasus cooperianus* – This is primarily a large river species that has been found at depths of 12 to 18 feet in sand and coarse gravel substrate (Parmalee and Bogan 1998).

Sheepnose – *Plethobasus cyphyus* – In medium size rivers this species is found in relatively fast current in less than two feet of water. In large rivers it has been found at depths of 12 to 15 feet. The most suitable substrate is a mixture of coarse sand and gravel (Parmalee and Bogan 1998) but it has been reported from mud, sand, gravel, or gravel and cobble substrates (Williams and Schuster 1989).

Clubshell – *Pleurobema clava* – This species was formerly very numerous in shoals and riffles of medium to large rivers (Parmalee and Bogan 1998). It was also found in substrates of gravel or mixed gravel and sand (Cummings and Mayer 1992).

Tennessee Clubshell – *Pleurobema oviforme* – This species may be found in small, shallow streams and rivers, in water less than two feet in depth. It is usually found in areas of good current with a substrate of coarse gravel and sand (Parmalee and Bogan 1998).

Rough Pigtoe – *Pleurobema plenum* – The rough pigtoe can be found in small rivers and in headwaters of medium rivers but it is most typical of large rivers. It has been found in impounded stretches of rivers at a depth of 12 to 15 feet on a substrate of firmly packed gravel and sand (Parmalee and Bogan 1998).

Pyramid Pigtoe – *Pleurobema rubrum* – This species inhabits rivers with strong current and a substrate of firm sand and gravel. In unimpounded rivers it may be found in water less than three feet in depth but may be found in over 20 feet of water in impounded stretches of river (Parmalee and Bogan 1998).

Fluted Kidneyshell – *Ptychobranchus subtentum* – This species can be found primarily in streams and small rivers. It inhabits riffles with fast currents with a sand or sand and gravel substrate at depths of two feet or less (Parmalee and Bogan 1998).

Rabbitsfoot – *Quadrula cylindrica cylindrical* – Rabbitsfoot inhabits medium to large rivers in mixed sand and gravel substrate (Cummings and Mayer 1992). It is found most frequently in current and at a depth of 9 to 12 feet (Parmalee and Bogan 1998).

Appalachian Monkeyface – *Quadrula sparsa* – Inhabits riffle and shoal areas with moderate current with a substrate of sand and gravel (Parmalee and Bogan 1998).

Salamander Mussel – *Simpsonaias ambigua* – This mussel inhabits medium to large rivers on mud or gravel bars or under slabs or flat stones (Cummings and Mayer 1992). It may also be found living under flat rocks in a sandy substrate (Parmalee and Bogan 1998).

Purple Lilliput Pearlymussel – *Toxolasma lividus* – This species has been reported from small to medium size rivers in mud, sand, and gravel substrates. It has also been found in a reservoir on shallow, rocky gravel points or sandbars (Parmalee and Bogan 1998).

Little Spectaclecase – *Villosa lienosa* – This species is typically found in shallow mud-bottomed creeks and small rivers with slow current (Parmalee and Bogan 1998). It has also been reported from streams with sand or gravel substrate (Cummings and Mayer 1992).

Cumberland Bean Pearlymussel – *Villosa trabalis* – The Cumberland bean is typically found in streams and small rivers. It inhabits gravel or sand and gravel substrate in riffle areas with a fast current (Parmalee and Bogan 1998).

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Attachment C

Lotic Habitat Association Matrix

Association	Temp.	Hab. Modifier (1)	Hab. Modifier (2)	Class	Common Name	Species
Lotic	Cold	ditches	low salinity; med-low O2;	CRUST	Neglected Fairy Shrimp	Eubranchipus neglecta
	Cold	Pool	low salinity; med-low O2;	CRUST	Neglected Fairy Shrimp	Eubranchipus neglecta
	Cold	temporary ponds	low salinity; med-low O2;	CRUST	Neglected Fairy Shrimp	Eubranchipus neglecta
	Cold	varible	quiet shallows in detrius strewn areas	FISH	Banded Sculpin	Cottus carolinae
	Cold	varible		FISH	Green Sunfish	Lepomis cyanellus
	Cold	varible	cover, eg. Brush, wood, boulders etc.	FISH	Longear Sunfish	Lepomis megalotis
	Cold	varible	little/no turbidity/free of exces silt	FISH	Longear Sunfish	Lepomis megalotis
	Cool	adjacent to riffles	pools in streams	FISH	Rainbow Darter	Etheostoma caeruleum
	Cool	adjacent to riffles	natural aquatic vegetation	FISH	Kentucky Snubnose Darter	Etheostoma rafinesquei
	Cool	adjacent to riffles		FISH	Striped Darter	Etheostoma virgatum
	Cool	adjacent to riffles		FISH	Northern Hogsucker	Hypentelium nigricans
	Cool	Glide	adjacent to riffles	FISH	Central Stoneroller	Campostoma anomalum
	Cool	Glide	base of riffles	FISH	Ashy Darter	Etheostoma cinereum
	Cool	Glide	above and below riffles	FISH	Arrow Darter	Etheostoma sagitta spilotum
	Cool	Glide	base of pools	FISH	Striped Darter	Etheostoma virgatum
	Cool	Glide	algae covered rocks	GASTR	Onyx Rocksnail	Leptoxis praerosa
	Cool	varible		FISH	Bluegill	Lepomis macrochirus
	Cool	wetlands	near permanent ponds	CRUST	Bluegrass Crayfish	Cambarus batchi
	Cool	wetlands	low salinity; med-low O2;	CRUST	Neglected Fairy Shrimp	Eubranchipus neglecta
	Warm	ditches	low salinity; med-low O2;	CRUST	Springtail Fairy Shrimp	Steptocephalus secti
	Warm	Glide		AMPHI	Mudpuppy	Necturus maculosus
	Warm	Glide		FISH	Lake Sturgeon	Acipenser fulvescens okasis

Association	Temp.	Hab. Modifier (1)	Hab. Modifier (2)	Class	Common Name	Species
	Warm	Glide		MUSSEL	Elktoe	Alasmadonta marginata
	Warm	Glide		MUSSEL	Cumberland, Elktoe	Alasmidonta atropurpurea
	Warm	Glide		MUSSEL	Cumberlandian Combshell	Epioblasma brevidens
	Warm	Glide		MUSSEL	Rough Pigtoe	Pleurobema plenum
	Warm	Glide		MUSSEL	Oyster Mussel	Epioblasma capsaeformis
	Warm	Glide		FISH	Striped Shiner	Luxilus (Notropis) chrysocephalus
	Warm	Glide		FISH	Paddlefish	Polydon spathula
	Warm	Glide		FISH	American Brook Lamprey	Lampetra appendix
	Warm	Glide		FISH	Tippecanoe Darter	Etheostoma tippecanoe
	Warm	Glide		FISH	Freshwater Drum	Aplodinotus grunniens
	Warm	Glide		FISH	Western sand darter	Ammocrypta clara
	Warm	Glide	little/no turbidity/free of excess silt	FISH	Western sand darter	Ammocrypta clara
	Warm	Glide		MUSSEL	Cumberland Papershell	Anodontoides denigratus
	Warm	Glide	pools/backwaters	FISH	Freshwater Drum	Aplodinotus grunniens
	Warm	Glide		FISH	Central Stoneroller	Campostoma anomalum
	Warm	Glide	pools in streams	FISH	White Sucker	Catostomus commersoni
	Warm	Glide	pools in streams	FISH	Redside Dace	Clinostomus elongatus
	Warm	Glide		FISH	Banded Sculpin	Cottus carolinae
	Warm	Glide	cover, eg. Brush, wood, boulders etc.	AMPHI	Eastern Hellbender	Cryptobranchus a. alleganiensis
	Warm	Glide		MUSSEL	Spectacle Case	Cumberlandia monodonta
	Warm	Glide	Vegetation, In Water Required	MUSSEL	Spectacle Case	Cumberlandia monodonta
	Warm	Glide		MUSSEL	Fanshell	Cyprogenia stegaria
	Warm	Glide		MUSSEL	Dromedary Pearlymussel	Dromus dromas
	Warm	Glide	riffle/shoals	MUSSEL	Cumberlandian Combshell	Epioblasma brevidens
	Warm	Glide	natural aquatic vegetation	MUSSEL	Oyster Mussel	Epioblasma capsaeformis

Association	Temp.	Hab. Modifier (1)	Hab. Modifier (2)	Class	Common Name	Species
	Warm	Glide		MUSSEL	Tan Riffleshell	Epioblasma florentina walkeri
	Warm	Glide	shallow riffles	MUSSEL	Northern Riffleshell	Epioblasma torulosa rangiana
	Warm	Glide		FISH	Bluebreast Darter	Etheostoma camurum
	Warm	Glide	head of riffles	FISH	Ashy Darter	Etheostoma cinereum
	Warm	Glide	natural aquatic vegetation	FISH	Ashy Darter	Etheostoma cinereum
	Warm	Glide	pools/backwaters	FISH	Ashy Darter	Etheostoma cinereum
	Warm	Glide	under flat rocks	FISH	Fantail Darter	Etheostoma flabellare
	Warm	Glide	pools in streams	FISH	Duskytail Darter	Etheostoma percnurum
	Warm	Glide	pools in streams	FISH	Kentucky Snubnose Darter	Etheostoma rafinesquei
	Warm	Glide	pools in streams	FISH	Arrow Darter	Etheostoma sagitta spilotum
	Warm	Glide		FISH	Cumberland Johnny Darter	Etheostoma susanae (nigrum susanae)
	Warm	Glide	shallow riffles	FISH	Tippecanoe Darter	Etheostoma tippecanoe
	Warm	Glide	base of riffles	FISH	Striped Darter	Etheostoma virgatum
	Warm	Glide		MUSSEL	Cracking Pearlymussel	Hemistena lata
	Warm	Glide	base of riffles	FISH	Northern Hogsucker	Hypentelium nigricans
	Warm	Glide	pools/backwaters	FISH	Ohio Lampery	Ichthyomyzon bdellium
	Warm	Glide	quiet shallows in detrius strewn areas	FISH	Northern Brook Lamprey	Ichthyomyzon fossor
	Warm	Glide	cover, eg. Brush, wood, boulders etc.	FISH	Mountain Brook Lamprey	Ichthyomyzon greeleyi
	Warm	Glide	little/no turbidity	FISH	American Brook Lamprey	Lampetra appendix
	Warm	Glide		MUSSEL	Pink Mucket	Lampsilis abrupta
	Warm	Glide	cover, eg. Brush, wood, boulders etc.	FISH	Warmouth	Lepomis gulosus
	Warm	Glide	little/no turbidity/free of exces silt	GASTR	Onyx Rocksnail	Leptoxis praerosa
	Warm	Glide	cover, eg. Brush, wood, boulders etc.	GASTR	Armored Rocksnail	Lithasia armigera
	Warm	Glide	pools in streams	FISH	Striped Shiner	Luxilus (Notropis) chrysocephalus
	Warm	Glide	cover, eg. Brush, wood, boulders etc.	FISH	Smallmouth Bass	Micropterus dolomieui

Association	Temp.	Hab. Modifier (1)	Hab. Modifier (2)	Class	Common Name	Species
	Warm	Glide	pools in streams	FISH	Largemouth Bass	Micropterus salmoides
	Warm	Glide	natural aquatic vegetation	AMPHI	Mudpuppy	Necturus maculosus
	Warm	Glide	pools in streams	FISH	River Chub	Nocomis micropogon
	Warm	Glide	little/no turbidity/free of exces silt	FISH	Palezone Shiner	Notropis albizonatus
	Warm	Glide	pools in streams	FISH	Palezone Shiner	Notropis albizonatus
	Warm	Glide	pools in streams	FISH	Sawfin Shiner	Notropis sp.3
	Warm	Glide	cover, eg. Brush, wood, boulders etc.	FISH	Northern Madtom	Noturus stigmosus
	Warm	Glide	pondweed and accumulated debris	FISH	Northern Madtom	Noturus stigmosus
	Warm	Glide		MUSSEL	Ring Pink Mussel	Obovaria retusa
	Warm	Glide		MUSSEL	Round Hickorynut	Obovaria subrotunda
	Warm	Glide	little/no turbidity/free of exces silt	FISH	Blotchside Logperch	Percina burtoni
	Warm	Glide		FISH	Logperch	Percina caprodes
	Warm	Glide	natural aquatic vegetation	FISH	Yellow Perch	Percina flavescens
	Warm	Glide	pools in streams	FISH	Longhead Darter	Percina macrocephala
	Warm	Glide	riffle/shoals	MUSSEL	White Wartyback	Plethobasus cicatricosus
	Warm	Glide	shallow riffles	MUSSEL	Orange-foot Pimpleback	Plethobasus cooperianus
	Warm	Glide	little/no turbidity/free of exces silt	MUSSEL	Clubshell	Pleurobema clava
	Warm	Glide		MUSSEL	Tennessee Clubshell	Pleurobema oviforme
	Warm	Glide	riffle/shoals	MUSSEL	Rough Pigtoe	Pleurobema plenum
	Warm	Glide	pools/backwaters	FISH	Paddlefish	Polydon spathula
	Warm	Glide	pools/backwaters	FISH	White Crappie	Pomoxis annularis
	Warm	Glide	riffle/shoals	MUSSEL	Appalachian Monkeyface	Quadrula sparsa
	Warm	Glide	under flat rocks	MUSSEL	Salamander Mussel	Simpsonaias ambigua
	Warm	Glide		FISH	Walleye-native populations only	Stizostedion vitreum
	Warm	Glide		MUSSEL	Little Spectaclecase	Villosa liensoa

Association	Temp.	Hab. Modifier (1)	Hab. Modifier (2)	Class	Common Name	Species
	Warm	Pool		FISH	Paddlefish	Polydon spathula
	Warm	Pool		FISH	Lake Sturgeon	Acipenser fulvescens okasis
	Warm	Pool	flats	MUSSEL	Cumberland, Elktoe	Alasmidonta atropurpurea
	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Rock Bass	Ambloplites rupestris
	Warm	Pool		FISH	Freshwater Drum	Aplodinotus grunniens
	Warm	Pool	adjacent to riffles	FISH	Duskytail Darter	Etheostoma percnurum
	Warm	Pool	Woody Structure Required	FISH	Channel Catfish	Ictalurus punctatus
	Warm	Pool	pools/backwaters	FISH	American Brook Lamprey	Lampetra appendix
	Warm	Pool		MUSSEL	Pocketbook	Lampsilis ovata
	Warm	Pool		MUSSEL	Green Floater	Lasmigona subviridus
	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Warmouth	Lepomis gulosus
	Warm	Pool	natural aquatic vegetation	FISH	Warmouth	Lepomis gulosus
	Warm	Pool	oxbow subsystems	FISH	Warmouth	Lepomis gulosus
	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Bluegill	Lepomis macrochirus
	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Smallmouth Bass	Micropterus dolomieui
	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Largemouth Bass	Micropterus salmoides
	Warm	Pool	pools in streams	FISH	Shorthead Redhorse	Moxostoma macrolepidotum
	Warm	Pool	natural aquatic vegetation	AMPHI	Mudpuppy	Necturus maculosus
	Warm	Pool	pools in streams	FISH	Palezone Shiner	Notropis albizonatus
	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Whitetail Shiner	Notropis galacturus
	Warm	Pool	natural aquatic vegetation	FISH	Yellow Perch	Percina flavescens
	Warm	Pool	pools/backwaters	FISH	Yellow Perch	Percina flavescens
	Warm	Pool	little/no turbidity/free of exces silt	FISH	Longhead Darter	Percina macrocephala
	Warm	Pool		MUSSEL	Sheepnose	Plethobasus cyphyus
	Warm	Pool	pools/backwaters	FISH	Paddlefish	Polydon spathula

Association	Temp.	Hab. Modifier (1)	Hab. Modifier (2)	Class	Common Name	Species
	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	White Crappie	Pomoxis annularis
	Warm	Pool	low salinity; med-low O2;	CRUST	Springtail Fairy Shrimp	Steptocephalus secti
	Warm	Pool	natural aquatic vegetation	FISH	Walleye-native populations only	Stizostedion vitreum
	Warm	Riffle		FISH	Gilt Darter	Percina evides
	Warm	Riffle		FISH	Mountain Brook Lamprey	Ichthyomyzon greeleyi
	Warm	Riffle		FISH	Banded Darter	Etheostoma zonale
	Warm	Riffle		FISH	Fantail Darter	Etheostoma flabellare
	Warm	Riffle		FISH	Greenside Darter	Etheostoma blennioides
	Warm	Riffle		MUSSEL	Tubercled-blossom Pearlymussel	Epioblasma torulosa torulosa
	Warm	Riffle		FISH	Central Stoneroller	Campostoma anomalum
	Warm	Riffle	natural aquatic vegetation	FISH	White Sucker	Catostomus commersoni
	Warm	Riffle		FISH	Banded Sculpin	Cottus carolinae
	Warm	Riffle	shallow riffles	MUSSEL	Dromedary Pearlymussel	Dromus dromas
	Warm	Riffle	riffle/shoals	MUSSEL	Cumberlandian Combshell	Epioblasma brevidens
	Warm	Riffle	riffle/shoals	MUSSEL	Yellow-blossom Pearlymussel	Epioblasma florentina florentina
	Warm	Riffle	riffle/shoals	MUSSEL	Tubercled-blossom Pearlymussel	Epioblasma torulosa torulosa
	Warm	Riffle		MUSSEL	Snuffbox	Epioblasma triquetra
	Warm	Riffle	natural aquatic vegetation	FISH	Greenside Darter	Etheostoma blennioides
	Warm	Riffle		FISH	Rainbow Darter	Etheostoma caeruleum
	Warm	Riffle	riffle/shoals	FISH	Bluebreast Darter	Etheostoma camurum
	Warm	Riffle	shallow riffles	FISH	Fantail Darter	Etheostoma flabellare
	Warm	Riffle	riffle/shoals	FISH	Spotted Darter	Etheostoma maculatum
	Warm	Riffle		FISH	Tippecanoe Darter	Etheostoma tippecanoe
	Warm	Riffle	natural aquatic vegetation	FISH	Banded Darter	Etheostoma zonale
	Warm	Riffle		MUSSEL	Cracking Pearlymussel	Hemistena lata

Association	Temp.	Hab. Modifier (1)	Hab. Modifier (2)	Class	Common Name	Species
	Warm	Riffle		FISH	Northern Hogsucker	Hypentelium nigricans
	Warm	Riffle	little/no turbidity/free of exces silt	FISH	Northern Brook Lamprey	Ichthyomyzon fossor
	Warm	Riffle	little/no turbidity/free of exces silt	FISH	Mountain Brook Lamprey	Ichthyomyzon greeleyi
	Warm	Riffle		FISH	Channel Catfish	Ictalurus punctatus
	Warm	Riffle	little/no turbidity	FISH	American Brook Lamprey	Lampetra appendix
	Warm	Riffle		MUSSEL	Pocketbook	Lampsilis ovata
	Warm	Riffle		FISH	Striped Shiner	Luxilus (Notropis) chrysocephalus
	Warm	Riffle	base of riffles	FISH	Palezone Shiner	Notropis albizonatus
	Warm	Riffle		MUSSEL	Little-wing Pearlymussel	Pegias fabula
	Warm	Riffle	shallow riffles	FISH	Gilt Darter	Percina evides
	Warm	Riffle	above and below riffles	FISH	Longhead Darter	Percina macrocephala
	Warm	Riffle		FISH	Olive Darter	Percina squamata
	Warm	Riffle		FISH	Paddlefish	Polydon spathula
	Warm	Riffle		MUSSEL	Fluted Kidneyshell	Ptychobranchus subtentum
	Warm	Riffle		GASTR	Domed Ancylid	Rhodacme elatior
	Warm	Riffle		MUSSEL	Cumberland Bean Pearlymussel	Villosa trabalis
	Warm	riffle/shoals	base of shoals	FISH	Northern Hogsucker	Hypentelium nigricans
	Warm	riffle/shoals		MUSSEL	White Wartyback	Plethobasus cicatricosus
	Warm	riffle/shoals		MUSSEL	Clubshell	Pleurobema clava
	Warm	riffle/shoals		MUSSEL	Appalachian Monkeyface	Quadrula sparsa
	Warm	riffle/shoals	little/no turbidity/free of exces silt	MUSSEL	Cumberland Bean Pearlymussel	Villosa trabalis
	Warm	riffles	cover, eg. Brush, wood, boulders etc.	INSECT	Pygmy Snaketail	Ophiogomphus howei
	Warm	sandbars		MUSSEL	Purple Lilliput Pearlymussel	Toxolasma lividus
	Warm	shoals	shallow riffles	FISH	Fantail Darter	Etheostoma flabellare
	Warm	shoals	little/no turbidity/free of exces silt	FISH	Gilt Darter	Percina evides

Association	Temp.	Hab. Modifier (1)	Hab. Modifier (2)	Class	Common Name	Species
	Warm	shoals		MUSSEL	Orange-foot Pimpleback	Plethobasus cooperianus
	Warm	shoals		MUSSEL	Sheepnose	Plethobasus cyphyus
	Warm	shoals		MUSSEL	Fluted Kidneyshell	Ptychobranchus subtentum
	Warm	springs		FISH	White Sucker	Catostomus commersoni
	Warm	springs	little/no turbidity	FISH	Banded Sculpin	Cottus carolinae
	Warm	temporary ponds	low salinity; med-low O2;	CRUST	Springtail Fairy Shrimp	Steptocephalus secti
	Warm	varible		FISH	Bluegill	Lepomis macrochirus
	Warm	varible	quiet shallows in detrius strewn areas	FISH	Banded Sculpin	Cottus carolinae
	Warm	varible		FISH	Green Sunfish	Lepomis cyanellus
	Warm	varible	cover, eg. Brush, wood, boulders etc.	FISH	Bluegill	Lepomis macrochirus
	Warm	varible	cover, eg. Brush, wood, boulders etc.	FISH	Longear Sunfish	Lepomis megalotis
	Warm	varible	little/no turbidity/free of exces silt	FISH	Longear Sunfish	Lepomis megalotis
	Warm	wetlands	near permanent ponds	CRUST	Bluegrass Crayfish	Cambarus batchi
	Warm	wetlands	low salinity; med-low O2;	CRUST	Springtail Fairy Shrimp	Steptocephalus secti

07/15/2003

Viability Assessment Report
For
General Standing Water Habitat Association

Prepared by:
John R. Omer
Daniel Boone National Forest

I. Description of the Habitat Association

The Daniel Boone National Forest (DBNF) has a multitude of small and large, permanent and temporary, named and unnamed bodies of standing water. The physiographic position, geology, soils, hydrology, and dominant vegetation all vary with the actual location of each body of water. All of these factors plus the size, depth, age and permanence of the body of water play an important role in the physical, chemical and biological makeup of these aquatic environments. The three large lakes on the DBNF, Cumberland, Cave Run and Laurel, are covered in other Habitat Association Reports.

Location

Small flood control lakes, ponds, temporary and permanent shallow water pools occur throughout most of the DBNF. Their size and distribution are widely variable. There are 9 small lakes and approximately 300 mapped ponds on the DBNF with approximately 8 and 30 miles of shoreline respectively (USDA Forest Service, 1996). In addition to the small lakes and ponds, numerous (possibly more than 1500) ridge-top, seasonal and forested pools have been established on the DBNF primarily on the Morehead and Stanton Districts (Biebighauser, 2001).

Geology, Hydrology and Dominant Vegetation

The DBNF contains parts of several physiographic regions or ecological subsections and portions of three major river systems: the Cumberland, Kentucky and Licking Rivers. The Forest also lies within or is bordered by several sections and subsections within the Eastern Broadleaf Forest provinces and the Central Appalachian Broadleaf-Coniferous Forest Province. The western part of the DBNF lies primarily within the Northern Escarpment, Southwestern Escarpment and Low Hills Belt subsections of the Northern Cumberland Plateau Section and is bordered to the west by the Highland Rim and Bluegrass sections. The eastern part of the DBNF lies primarily within the Rugged Eastern Hills subsection. The southern and southeastern boundaries of the Forest also encompass the Jellico Mountains subsection of the Cumberland Mountains Section (USDA Forest Service, 2001). Vegetation will vary with the size and type of water body. Seasonal ponds of all types may have rushes, bulrushes, caric sedges, Nepal browntop and lowland buttonweed. Shallow permanent ponds will frequently have ceric sedges, rushes, bulrushes, redtop panic grass, Swamp Beggar’s tick and Carolina willow. Larger deep ponds and smaller lakes may have cattail, Woolly Bulrush and black and carolina willow. Precipitation in the area occurs throughout the year with seasonal variation.

II. Current Status of the Habitat Association on the Daniel Boone National Forest

The landscape of the area that is now the DBNF has changed dramatically since the 1800's when the dominant use was small-scale subsistence farming. Logging and land clearing for agriculture accelerated in the early 1900's and by 1930 most of eastern Kentucky had been cleared. Faced with economic necessity, many people either abandoned or sold their land to the Federal Government in the 1920's and 1930's under the Weeks Act. From the 1920's to the 1970's mining companies stripped and deep mined coal on adjacent private lands (USDA Forest Service, 2001).

Historically, natural bodies of standing water may have been more common than they are today in what is now the DBNF. Beginning in the 1940's many small ponds were established for watering livestock on private land through programs administered by the Soil Conservation Service (Biebighauser, 2001). When this land was acquired for the DBNF some tracts had these existing standing water bodies on them. Ponds were established on the DBNF to provide water for forest fire suppression in the 1960's. A number of small lakes were established in the early 1970's by the Soil Conservation Service for flood control as directed by Public Law 566 (Biebighauser, 2001). Past and current DBNF practices have established and maintained numerous water sources for a variety of purposes. This has increased the total number of individual bodies of water on the Forest.

III. Management Needs: Recommendations for the Conservation of Habitat to Ensure Species Viability

The majority of the smaller lakes, ponds, and other standing water found on the DBNF are man-made. These bodies of water provide habitat for numerous species for which continued expectation of existence on the forest is at risk (see Appendix A). Habitat management includes protection and improvement, and in some cases creating more bodies of standing water, to ensure species viability. Protection involves preventing actions or alterations, to the habitat, that adversely affect species viability.

The desired goal would be to maintain or exceed State water quality standards for aquatic biodiversity; maintain and restore water quality necessary to support healthy aquatic ecosystems and to ensure survival, growth, reproduction, and migration of aquatic dependent species; maintain and/or restore the biological, physical, and chemical integrity of aquatic ecosystems (USDA Forest Service, 2001).

The desired future condition of this habitat association is to maintain, improve, and/or establish more standing water within the Forest. Manage land surrounding these areas in a way that enhances or does not negatively impact the species viability of organisms living there. Ensure a high likelihood that species within this association will persist or increase on the forest over the planning period.

Forest-Wide Standards

- Follow direction in FSM 2630 (Management of Wildlife and Fish Habitat) and FSM 2670 (Threatened, Endangered, and Sensitive Plants and Animals).
    - o *Rationale: These provide guidance for management decisions specific to wildlife, fish, and PETS species.*
- Follow guidelines in FSH 2609.13 (Wildlife and Fisheries Program Management Handbook).
    - o *Rationale: These provide guidance for management decisions specific to wildlife and fisheries.*
- Meet or exceed all Federal, State, and local water quality standards for aquatic biodiversity.
    - o *Rationale: The National Forest Management Act of 1976 requires the Forest Service to maintain or enhance water quality, which turn helps maintain healthy aquatic ecosystems.*
- Create more ponds and temporary and permanent shallow water pools throughout the DBNF.
    - o *Rationale: The majority of these bodies of water are concentrated on the Morehead and Stanton Ranger Districts. It has been shown that these pools are used by species at risk of loosing population viability on the DBNF specifically several bat species use these areas as drinking and feeding habitat. They are essential for female bats when pregnant and/or lactating because they have much smaller foraging and flight ranges. Creating more pools may increase these species viability.*
- Established and/or suspected bald eagle nesting sites will be managed following the "Habitat Management Guidelines for the Bald Eagle in the Southeast Region"
    - o *Rationale: Protecting bald eagle nesting sites may increase species viability.*
- National Forest vegetation management will not be proposed in the area adjacent to these small lakes, ponds, or areas of standing water unless the objective of the management is habitat improvement or will have beneficial or no adverse effect on species that use this association.
    - o *Rationale: Management activities are sometimes necessary to maintain or enhance individual species habitats.*
- Manage special dispersed recreation activities. Schedule and regulate use of facilities, time of year, number of users, and designate use areas.
    - o *Rationale: Limit adverse impact on species that use these aquatic areas as habitat.*

- Supplement habitat with naturally and artificially created nesting, roosting, and perching structures if these are limiting factors. Provide wood duck nest boxes and create snags in appropriate habitat.
    - *Rationale: Species viability may be increased if these are limiting factors in the area.*
- Provide fish attractors in areas with limited cover in ponds and lakes of appropriate size.
    - *Rationale: Increase lake and pond productivity for species dependent on fish as a food source, such as the bald eagle, wood duck, and hooded merganser.*
- Comply with water goals as specified in the Clean Water Act and other Congressional mandates.
    - *Rationale: The Clean Water Act mandates the maintenance of biological integrity; this would help to enhance and maintain habitat viability.*
- Determine if applicable water quality standards are being met.
    - *Rationale: This will help insure maintenance or improvement of the habitat association and the viability of the species that inhabit it.*

Indiana Bat

Forest-wide General Direction and Standards and Guidelines Needed to Maintain Species Viability

Provide upland water sources of appropriate design and at appropriate frequencies (Unless otherwise noted, the standards and guidelines are current Forest Plan direction.)

- Upland water sources should be provided at a frequency of one every 1/2 mile in upland areas and along ridgetops.
    - *Rationale: Bats make frequent use of upland water sources, especially during the maternity season. Well-distributed water sources will enhance habitat suitability.*
- Water sources should include a mixture of permanent ponds and seasonal pools.
    - *Rationale: A diversity of watering sources will provide for suitable sites during seasonal and yearly changes in precipitation.*
- Water sources should be adjacent to mature forest and/or woods road corridors whenever possible and should contain at least one flight corridor for bats that will not quickly become cluttered with young tree growth.
    - Rationale: Mature forest provides overhead cover to lessen avian predation on bats. Woods roads provide good, unobstructed, flight corridors for bats while maintaining

overhead cover. Natural or artificial flight corridors are important to allow unobstructed access to water sites by bats.

- Water sources should be maintained in a condition where they are suitable as water sources for bats and other wildlife, and as breeding habitat for resident amphibians and invertebrates.
  - Rationale: Periodic maintenance of flight corridors may be necessary to maintain the vegetation in a desirable condition. Some downed woody debris is desirable in waterholes and ponds for amphibian and invertebrate habitat.

Restrict Indiana bat use of contaminated water sources (Unless otherwise noted, the standards and guidelines are current Forest Plan direction.)

- All sources of potentially toxic standing water or water sources that may harm Indiana bats or other wildlife (e.g. brine pits, oil catch basins, etc.) should be filled, covered, or otherwise modified to prevent animals from attempting to drink from them.

  Rationale: These water sources pose a serious threat to bats or birds attempting to use them as a source of water. Highly toxic materials may be ingested with the water. Individuals may also become entrapped in ponds containing waste materials from mining or drilling operations.

IV. Management Needs: Monitoring and Inventory to Ensure Species Viability

There are several species that use these scattered bodies of water that are at risk of loosing their population viability (see appendix A). Inventories should be conducted to collect baseline data on the presence, population size, and timing and frequency of use by these species.

- Habitat persistence and health should be regularly monitored while periodic monitoring should be conducted to insure individual species viability. This could be accomplished in cooperation with KDFWR and other state and federal agencies. (Moderate priority)

- If the current status of a species in this habitat association is not known, then inventory of species that are potentially at risk of loosing population viability should be carried out. The general strategy is to document existing habitat and/or species condition and status, and then assess for degradation or potential improvement. (High priority)

- Information on the location, dimensions, and type of water bodies on the DBNF should be collected and entered into a GIS database. This information would be used in the management of species at risk of loosing population viability that use these habitats and would help determine whether there is a need, and where that need may be, to establish more of this habitat type. It would also be used in management decisions on the DBNF to prevent potentially adverse impacts to these species. Once established the database should be continuously kept up to date. (High priority)

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Attachment A.

Species List: General Standing Water Habitat Association

Class	Common Name/ Species
AMPHIBIAN	Jefferson Salamander/ *Ambystoma jeffersonianum*
	Marbled Salamander/ *Ambystoma opacum*
	Mountain Dusky Salamander/ *Desmognathus ochrophaeus*
	Black Mountain Salamander/ *Desmognathus welteri*
	Four-toed Salamander/ *Hemidactylum scutatum*
	Mudpuppy/ *Necturus maculosus*
	Wehrle's Salamander/ *Plethodon wehrlei*
	Green Frog/ *Rana clamitans*
	Wood Frog/ *Rana sylvestris*
BIRD	Wood Duck/ *Aix sponsa*
	Bald Eagle/ *Haliaeetus leucocephalus*
	Least bittern/ *Ixobrychus exilis*
	Hooded Merganser/ *Lophodytes cucullatus*
	Pied-billed Grebe/ *Podilymbus podiceps*
FISH	Rock Bass/ *Ambloplites rupestris*
	Northern Hogsucker/ *Hypentelium nigricans*
	Bluegill/ *Lepomis macrochirus*
	Smallmouth Bass/ *Micropterus dolomieui*
	Largemouth Bass/ *Micropterus salmoides*
	Yellow Perch/ *Perca flavescens*
	White Crappie/ *Pomoxis annularis*
MAMMAL	Beaver/ *Castor canadensis*
	Kentucky Red-backed Vole/ *Clethrionomys gapperi maurus*
	Southeastern myotis/ *Myotis austroriparius*
	Gray Bat/ *Myotis grisescens*
	Eastern Small-footed Bat/ *Myotis leibii*
	Indiana Bat/ *Myotis sodalis*
	Masked Shrew/ *Sorex cinereus cinereus*
PLANT	Engelmann’s quillwort/ *Isoetes engelmannii*
	Sweet waterlily/ *Nymphaea odorata*
	Spotted Pondweed/ *Potamogeton pulcher*
	Sphagnum moss/ *Sphagnum macrophyllum*
	Eelgrass/ *Vallisneria Americana*
REPTILE	Eastern Ribbon Snake/ *Thamnophis sauritus sauritus*

Attachment B.

General Standing Water Habitat Association Species/Habitat Relationships with References

AMPHIBIAN

Jefferson Salamander – *Ambystoma jeffersonianum* – Jefferson salamander is found primarily in shady deciduous forests or mixed woods, low woods and bottomlands. This salamander requires abundant leaf litter, rocks, decomposing logs and stumps. During breeding season, the Jefferson salamander requires temporary ponds, ideally with a pH between 5 and 6 (DeGraff and Rudis, 1986). This salamander is an opportunistic feeder consuming small invertebrates. (Wilson, 1995).

Marbled Salamander – *Ambystoma opacum* – The marbled salamander occupies a variety of habitats, ranging from pine forests to mixed pine-hardwoods and apparently does best in areas where abundant leaf litter and fallen logs provide shelter. This salamander will spend much of its' time in burrows, leaf litter or under bark and logs. During late fall, the marbled salamander moves into bottomland hardwoods and deposits it's eggs terrestrially. This salamander requires areas subject to fluctuating water levels for breeding and larvae development. The marbled salamander will eat a variety of food items such as insects, other small arthropods, earthworms, snails, and slugs. (Wilson, 1995).

Mountain Dusky Salamander – *Desmognathus ochrophaeus* – The mountain dusky salamander has the broadest altitudinal distribution of any desmognathine salamander, reaching the highest elevations in the eastern United States. These salamanders become more terrestrial at higher elevations, apparently in response to increased humidity. (Hairston, 1949; Tilley, 1973c). At high elevations, the mountain dusky salamander prefers cool, moist floors of conifer forests (USGS, 2001); at low elevations, this species occurs primarily under rocks, logs or leaves near stream margins, springs, or seepage areas, where the ground is water saturated. Adults will often move far into the adjacent woodlands, particularly during rains. The mountain dusky salamander requires mesic woodlands, usually hardwoods or mixed pine-hardwood, with springs, seeps or rocky streams. In winter, this salamander is known to congregate in springs or seepage areas. (USGS, 2001). Wet, mossy, rock faces are preferred by this species. The mountain dusky salamander's diet includes small arthropods and earthworms. (Wilson, 1995)

Black Mountain Salamander – *Desmognathus welteri* – The type locality for the Black Mountain Salamander is Black Mountain, Harlan County, Kentucky. The range extends through the southeastern two thirds of Kentucky and adjacent Virginia and Tennessee. The Black Mountain Salamander is found in and around mountain streams with moderate to weak current. Occasionally it is found associated with wet, rocky seeps. The black mountain salamander is primarily a nocturnal feeder, which preys on worms, arthropods and crustaceans. The black mountain salamander requires silt-free streams with rocky bottoms. They spend most of the daylight hours concealed under rocks. (Wilson, 1995)

Four-toed Salamander – *Hemidactylum scutatum* – The four-toed salamander is usually associated with sphagnum bogs or slow-moving streams with abundant moss or sedges adjacent to woodland areas. Adults live under rocks, logs, leaves or moss in maple-beech and other hardwood forests. They can also be observed in coniferous woods such as loblolly, short-leaf pine, and Virginia pines. The larvae live in pools, bogs or slow-moving streams with moss or sedges (Neill, 1963). The four-toed salamander is terrestrial as an adult, requiring woodlands near sphagnum ponds, streams or bogs. The larvae are aquatic and require a permanent water source. The four-toed salamander is an opportunistic feeder with a diet consisting of small arthropods and worms. (Wilson, 1995).

Mudpuppy – *Necturus maculosus* – The mudpuppy is entirely aquatic, inhabiting lakes, pond, rivers, streams, and other permanent bodies of water. They prefer either weedchoked waters or those with abundant shelter in the form of debris, rocks, mud, and/or leaf beds. They require unpolluted, clean water (Wilson, 1995)

Wehrle's Salamander – *Plethodon wehrlei* – The Wehrle’s salamander is found in the Appalachian Mountains from extreme southwestern New York southward through Pennsylvania, southeastern Ohio, West Virginia, and Virginia to Stokes County, North Carolina. A disjunct enclave occurs along the Kentucky-Virginia-Tennessee border. Wehrle’s salamander is commonly found on wooded hillsides where it hides under rocks and less frequently under and within logs. It has been found near cave entrances, within deep rock crevices and in old second growth, mixed deciduous and coniferous forests. Wehrle’s salamander requires moist wooded hillsides with surface debris in the form of rocks, logs and leaf litter. In early summer, females deposit a small cluster of eggs in damp logs, soil, or moss. She will remain with the eggs until they hatch. This salamander’s diet consists of small invertebrates, especially insects, spiders and earthworms. (Wilson, 1995)

Green Frog – *Rana clamitans* – This frog is a semi-aquatic species occupying many of the same habitats as the large bullfrog, e.g. permanent bodies of water. The green frog can be observed in shallow water, such as springs, seeps, ponds, reservoirs, creeks, beaver ponds, ditches, bogs, floodplain pools, and swamps. The green frog requires semi-permanent water and is an opportunistic feeder. The green frog’s diet includes arthropods, snails and worms (Martof et al., 1980). The green frog prefers ponds, floodplain swamps or marshy habitat with grassy edges and emergent vegetation. (Wilson, 1995)

Wood Frog – *Rana sylvestris* – The wood frog lives in or near moist woods, hardwood valleys and occasionally white pine-hemlock, and upland pine forest types. The wood frog breeds in open-water ponds, slow-moving portions of streams and roadside ditches. The wood frog’s diet consists mainly of insects. Adults require upland forest areas with logs, stumps and rocks for overwintering and moist woods with standing water during the late winter months. (Wilson, 1995)

BIRD

Wood Duck – *Aix sponsa* – These birds live around a variety of aquatic habitats that have cavities available for nesting. Swamps, wooded streams, lakes, ponds, reservoirs, and marshes provide suitable habitat. Nesting is in live or dead trees, within cavities, hollow limbs, and even abandoned pileated woodpecker holes. Trees utilized are usually near or above water—often in sycamore and maples (Mengel 1965). Artificial nest boxes are widely used. Birds forage in shallow water for aquatic plants, insects, and small fish. In the winter, wood ducks often eat acorns. The wood duck would be likely to be found utilizing the forest immediately adjacent to rivers, larger streams, lakes, and permanent ponds for nesting.

Bald Eagle – *Haliaeetus leucocephalus* – This federally listed species is dependent on aquatic habitat, primarily river floodplains, lakes, and natural and human-built reservoirs. It utilizes both standing and flowing fresh water sources (and salt water, in coastal areas) that have large trees suitable for nesting, perching and roosting. Suitable trees are at least 20" dbh in size and usually growing near the water (Hamel, 1992). In Kentucky, the birds have nested and wintered around wetland/floodplain habitats and reservoirs resulting from the impoundment of rivers (e.g., Laurel River Lake on the DBNF). Wintering birds are known to occur on major impoundments on the DBNF. Records of attempted nesting exist for Laurel River Lake although no active nests are currently known to exist. The bald eagle would be attracted to the forest along large rivers for nesting and wintering.

Least bittern – *Ixobrychus exilis* – This bittern species is found around aquatic habitats that have tall vegetation, such as cattails and rushes, in which to conceal themselves and their nests. Swamps, marshes, ponds and shallow lake edges are commonly used. In Kentucky, least bitterns have also been found nesting in artificial situations, including reservoirs, waterfowl management impoundments, and fish hatchery brood ponds (Palmer-Ball, 1996). Foraging is in shallow water, mud, and aquatic vegetation (Hamel, 1992).

Hooded Merganser – *Lophodytes cucullatus* – This species of waterfowl requires wooded areas with clear water streams, rivers, swamps, ponds, and lakes with cavity trees present (DeGraaf et. al., 1991). Usually forages in freshwater situations such as swamps, ponds or lakes (Hamel, 1992). This species is seldom found far from floodplain situations and usually requires a good stand of fairly mature forest nearby for nest sites (Palmer-Ball, 1996). They require cavities for nesting and may utilize artificial cavities originally constructed for wood ducks (Bellrose, 1980). The hooded merganser would be particularly attracted to the backwater areas of rivers and larger streams, where it can occasionally be found foraging and nesting.

Pied-billed Grebe – *Podilymbus podiceps* – The destruction of wetland habitat has led to a decrease in numbers of this species. Marshes, water impoundments, and shallow edges of lakes and ponds provide habitat for these birds. Marshy, shallow water with abundant emergent vegetation in which to nest is required during the breeding season. During winter, the birds use similar habitat, but with an increased use of open water. On 13 June 2000, an MSU grad student observed a pied-billed grebe and four young on an USFS-built wetland near Beaver Creek, on the Morehead R.D. (Biebighauser 2001).

FISH

Rock Bass – *Ambloplites rupestris* – This species can be found associated with sheltered pool areas in cold to warm creeks and rivers. They are occasionally associated with rocky shores in reservoirs. They are usually found in the cover of roots and brush (Etnier and Starnes 1993). Burr and Warren (1986) reports the rock bass in pools from clear upland streams and rivers with boulder, cobble, pebble, and gravel substrate, and associated with emergent vegetation or instream shelter.

Northern Hogsucker – *Hypentelium nigricans* – The northern hogsucker prefers warmwater, riffles or adjacent areas, of moderate sized creeks and small rivers. It can be found in coldwater streams, tiny creeks, large rivers, and occasionally in reservoirs. It requires shallow gravel areas for spawning (Etnier and Starnes 1993). Preferred substrates include bedrock, cobble, pebble, gravel, and sand (Burr and Warren 1986).

Bluegill – *Lepomis macrochirus* – This species can be found in nearly all sizes of standing and moving water. It is most abundant in lakes and ponds and prefers shallow water with the cover of vegetation, woody debris, and/or rocks (Etnier and Starnes 1993). It typically occurs in clear, quiet waters where the bottom is of mixed cobble, pebble, gravel, sand, mud, and organic debris (Burr and Warren 1986).

Smallmouth Bass – *Micropterus dolomieui* – The smallmouth bass can be found in clear upland creeks, rivers, lakes and reservoirs. It prefers areas with submerged logs, stumps and rock outcrops and some current if in a stream. In reservoirs, steep rocky slopes along submerged river and creek channels are preferred (Etnier and Starnes 1993). In lotic waters it is generally associated with clean pools with substrates of boulder, cobble, pebble, and gravel (Burr and Warren 1986).

Largemouth Bass –*Micropterus salmoides* – The largemouth bass inhabits sluggish waters in large streams, lakes and reservoirs. This species is more tolerant of turbidity than other members of the genus (Etnier and Starnes 1993). It is often found in association with vegetated littoral areas, standing timber, stumps and other cover. It can be found over substrates containing cobble, pebble, gravel, sand, mud, and organic debris (Burr and Warren 1986).

Yellow Perch – *Perca flavescens* – The yellow perch inhabits streams and lakes and prefers quiet waters often associated with rooted aquatic vegetation (Etnier and Starnes 1993). Found in greatest numbers in clear waters with a substrate of muck, organic debris, sand or gravel and an abundance of rooted aquatic vegetation (Trautman 1981).

White Crappie – *Pomoxis annularis* – The white crappie inhabits sluggish streams and lakes and is quite tolerant of turbidity. It prefers areas with plenty of cover such as brush and other obstructions. Nests are constructed near the cover of brush or overhanging banks in shallow protected areas such as coves or deeper overflow pools (Etnier and Starnes 1993). The white crappie is also found in large ponds and impoundments, over hard and soft bottoms, and areas containing aquatic vegetation, submerged brush, logs, stumps, and tree roots (Trautman 1981). It can also be found in rivers and large rivers over substrates of gravel, sand, mud, and organic debris often in association with emergent and aquatic bed vegetation, scrub-shrub, forested, and instream shelter (Burr and Warren 1986).

MAMMAL

Beaver – *Castor canadensis*

Kentucky Red-backed Vole – *Clethrionomys gapperi maurus* – The Kentucky red-backed vole is known to inhabit the higher elevations of the conifer-northern hardwood forest type on the Redbird Ranger District, DBNF. It is found in dense forest habitat, cool damp woodlands with down logs, and shaded rock talus areas usually on north facing slopes. Moss covered rocks are a common occurrence in this species favored habitat. The red-backed vole feeds on a variety of nuts, seeds berries, bark and roots. Its distribution is likely to be controlled, in part, on the availability of free water because this vole is known to drink large quantities.

Southeastern myotis – *Myotis austroriparius* – The Southeastern myotis rarely occurs on the DBNF which is considered to be on the very edge of the species range. This species utilizes limestone caves for hibernation and is difficult to detect because of its habit of wedging itself far back in cracks and crevices in the ceilings and walls of caves. The Southeastern myotis roosts almost exclusively in caves during the winter and some cave use occurs in the summer. These bats also use hollow trees as summer and maternity roosts. Foraging areas are usually over riparian habitat bordering streams, lakes and ponds. Aquatic insects such as small beetles, moths and mosquitoes form the basis of the food species for the Southeastern myotis.

Gray Bat – *Myotis grisescens* – No large hibernating, bachelor or maternity colonies of gray bats are currently known to exist on the DBNF. Gray bats have been observed in small numbers in caves and in riparian forest areas at several locations on the forest. Gray bats roost in limestone caves year-round, but seasonally they may utilize different caves during the summer and winter. They may migrate between caves or sometimes can be considered as residents of a relatively small area. Gray bats feed almost exclusively over water in riparian forest areas. Emerging aquatic insects such as beetles, moths, mayflies, stoneflies and caddisflies make up the bulk of their diet.

Eastern Small-footed Bat – *Myotis leibii* – The eastern small-footed bat likely occurs in forested areas throughout the DBNF. Foraging habitat is often associated with riparian areas, but may occur elsewhere in the forest or forest edge. Summer roosting habitat includes caves, under rocks, bridges (in expansion joints), hollow trees and under exfoliating bark. Food habits are thought to be almost exclusively flying insects associated with riparian habitats. Reproducing females have been found in Eastern Kentucky, but the species is believed to be most common on the DBNF during the winter. Winter hibernation often occurs in relatively cold areas of low humidity just within the entrance of caves or mines. Thus, the eastern small-footed bat may be vulnerable to freezing in severe winters and to human disturbance. The species also hibernates in rock shelters and in fissures within clifflines.

Indiana Bat – *Myotis sodalis* – The DBNF is known to support both winter and summer colonies of the Indiana bat. During the non-hibernation season Indiana bats are likely to occur throughout the DBNF. Some males periodically roost in caves during the summer, but most, along with females, roost under exfoliating bark or in hollow cavities in a variety of dead and alive trees. Roost trees with some sun exposure seem to be preferred because they are warmer. Indiana bats forage for insects in a wide variety of forest habitats ranging from riparian corridors to upland oak to higher elevation ridgetops. Forest canopy ranges from relatively closed to fairly open and Indiana bats sometimes forage in and near grass areas at the forest edge. An open forest understory enhances the bats ability to navigate within the forest stands. Available water in the form of shallow waterholes or ponds enhances general habitat suitability and utilization.

Maternity populations are known to exist on the DBNF. Female Indiana bats are known to use multiple roost trees during the lactation period and may forage and roost up to 2 ½ miles from their primary roost trees. During the winter Indiana bats hibernate in several cool/cold limestone caves on the DBNF. These bats gather in large clusters on cave ceiling and need protection from human disturbance during this time of year. Significant hibernation caves occur on the Stanton, London and Somerset Ranger Districts. Hibernation caves are most often, but not always, associated with limestone clifflines. Maintaining forest canopy around hibernation caves helps maintain microclimate conditions and provides nearby roosting and foraging habitat, particularly during the fall swarming season.

Masked Shrew – *Sorex cinereus cinereus* – The masked shrew is associated with higher elevations of the conifer-northern hardwood habitat association. They are found in deep, moist woodlands and prefer areas of thick leaf mold and decaying fallen logs. Masked shrews may occur in small populations on the Redbird Ranger District, DBNF. The species may occur in other forested habitats, particularly near stream head seeps, that have the right conditions to support numerous invertebrate food species and moisture conditions. The dens of masked shrews are located in cavities in logs or snags, under logs or in shallow burrows. In streamside areas they may be found in communities dominated by hemlock/rhododendron. The diet of this species consists of a variety of invertebrates and small vertebrate animals. They prefer moist habitats and access to free water may be important.

Beaver – *Castor Canadensis* –

PLANTS

Engelmann's quillwort – *Isoetes engelmannii* – is a semi-aquatic species. The plants can survive entirely submerged, or for several months out of water if the soil remains moist. At the time spores are released, the leaf bases must be submerged for sexual reproduction to be successful. The plants are generally in shallow water (under 2 feet deep) and are found in both permanent and seasonal water including ruts, roadside ditches, ponds, lake margins, and occasionally in streamhead wetlands and streams.

Sweet waterlily – *Nymphaea odorata* is a true aquatic species known from the northern US to the Gulf Coast. Submerged roots are a requirement. At least part of the submergence requirement is for protection against freezing in winter. Relatively still water is also required. This can be a protected pool in a stream or lake or on a small pond. It is known from many sites in Kentucky but only one recently discovered site on the DBNF. It is probable that waterfowl introduced the plant to these created wetlands.

Spotted Pondweed – *Potamogeton pulcher* – is a coastal plain species with scattered interior stations. It is found in shallow, quiet water and muddy shores. The DBNF records are from ponds and slow stream margins.

Sphagnum moss – *Sphagnum macrophyllum* – is a coastal plain species ranging from Newfoundland to Florida then west to Texas. In is known from the Cumberland Plateau in Tennessee and Kentucky. The Kentucky site is on the Morehead District of the DBNF. Throughout its range it is found in shallow, quiet water in lakes, ponds, roadside ditches, and southward in gum-cypress swamps. On the DBNF, it is known from one small pond near Cave Run Lake, where it covers much of the surface.

Eelgrass – *Vallisneria Americana* – is a true aquatic species, for which submerged roots are a requirement. Relatively still water is also required, as the leaves are thin and fragile. The plants are occasionally found in streams in areas of sluggish current, but are also found in ponds, including stripmine ponds, and lakes. Relatively high quality water is required by the species.

REPTILES

Eastern Ribbon Snake – *Thamnophis sauritus sauritus* – This is a semiaquatic species almost always found close to the shallow water of bogs, marshes, swamps, ponds, streams, and weedy lake shorelines. Other low, wet places in which it is encountered include meadows and grassy roadside ditches. Occupied areas tend to be open, but with an abundance of ground cover, such as grasses and sedges, and bushes in which the snakes can sun themselves. These snakes often climb into low vegetation, although rarely more than 4 feet off the ground (Barbour 1971). When startled, they swim on the surface of the water. Deep water is normally avoided, and fleeing Ribbon Snakes skirt the shore, threading their way through vegetation and getting lost from sight with amazing rapidity (Conant and Collins 1991). Their diet consists of small fish and amphibians.

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Attachment C.

General Standing Water Habitat Association Matrix

Habitat	Temp.	Habitat Modifiers	Habitat Modifiers 2	Class	Species	Common Name
General Standing Water	Warm	Glide	submerged roots	P-DIC	Nymphaea odorata	Southern Fragrant Waterlily
	Warm	Pool	pools/backwaters	P-MON	Potamogeton pulcher	Spotted Pondweed
	Warm	Pool	shallow water	P-FER	Isoetes engelmannii	Engelman's Quillwort
	Warm	Pool	shallow water	P-MOS	Sphagnum macrophyllum	Large-leaved sphagnum
	Warm	Pool	submerged roots	P-DIC	Nymphaea odorata	Southern Fragrant Waterlily
	Warm	Pool	submerged roots	P-MON	Vallisneria americana	Eelgrass
Lentic	Cold	Pool		FISH	Hypentelium nigricans	Northern Hogsucker
	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Ambloplites rupestris	Rock Bass
	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Lepomis macrochirus	Bluegill
	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Micropterus dolomieui	Smallmouth Bass
	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Micropterus salmoides	Largemouth Bass
	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Pomoxis annularis	White Crappie
	Warm	Pool	natural aquatic vegetation	FISH	Perca flavescens	Yellow Perch
	Warm	Pool	pools/backwaters	FISH	Perca flavescens	Yellow Perch
Lotic	Cold	Glide	cover, eg. Brush, wood, boulders etc.	FISH	Ambloplites rupestris	Rock Bass
	Cold	Riffle	skip	FISH	Hypentelium nigricans	Northern Hogsucker
	Cool	Glide	pools in streams	FISH	Micropterus dolomieui	Smallmouth Bass
	Warm			FISH	Hypentelium nigricans	Northern Hogsucker
	Warm	adjacent to riffles	skip	FISH	Hypentelium nigricans	Northern Hogsucker
	Warm	Glide	base of riffles	FISH	Hypentelium nigricans	Northern Hogsucker
	Warm	Glide	cover, eg. Brush, wood, boulders etc.	FISH	Micropterus dolomieui	Smallmouth Bass
	Warm	Glide	natural aquatic vegetation	FISH	Perca flavescens	Yellow Perch
	Warm	Glide	pools in streams	FISH	Micropterus salmoides	Largemouth Bass
	Warm	Glide	pools/backwaters	FISH	Pomoxis annularis	White Crappie
	Warm	Glide	shallow water	P-MON	Potamogeton pulcher	Spotted Pondweed
	Warm	Glide	submerged roots	P-MON	Vallisneria americana	Eelgrass
	Warm	Pool	cover, eg. Brush, wood, boulders etc.	FISH	Ambloplites rupestris	Rock Bass
	Warm	Riffle	skip	FISH	Hypentelium nigricans	Northern Hogsucker

Habitat	Temp.	Habitat Modifiers	Habitat Modifiers 2	Class	Species	Common Name
	Warm	riffle/shoals	base of shoals	FISH	Hypentelium nigricans	Northern Hogsucker
	Warm	varible	cover, eg. Brush, wood, boulders etc.	FISH	Lepomis macrochirus	Bluegill
	Warm	varible	pools/backwaters	P-FER	Isoetes engelmannii	Engelman's Quillwort
	Warm	varible	skip	FISH	Lepomis macrochirus	Bluegill
				AMPHI	Desmognathus welteri	Black Mountain Salamander
				AMPHI	Hemidactylum scutatum	Four-toed Salamander
				AMPHI	Rana clamitans	Green Frog
				AMPHI	Ambystoma Jeffersonianum	Jefferson Salamander
				AMPHI	Ambystoma opacum	Marbled Salamander
				AMPHI	Desmognathus ochrophaeus	Mountain Dusky Salamander
			natural aquatic vegetation	AMPHI	Necturus maculosus	Mudpuppy
				AMPHI	Plethodon wehrlei	Wehrle’s Salamander
				AMPHI	Rana sylvestris	Wood Frog
				BIRDS	Lophodytes cucullatus	Hooded Merganser
				BIRDS	Ixobrychus exilis	Least bittern
				BIRDS	Podolymbus podiceps	Pied-billed Grebe
				BIRDS	Aix sponsa	Wood Duck
				MAMMALS	Castor Canadensis	Beaver
				MAMMALS	Myotis leibii	Eastern Small-footed Bat
				MAMMALS	Myotis grisescens	Gray Bat
				MAMMALS	Myotis sodalis	Indiana Bat
				MAMMALS	Clethrionomys gapperi maurus	Kentucky Red-backed Vole
				MAMMALS	Sorex cinereus cinereus	Masked Shrew
				MAMMALS	Myotis austroriparius	Southeastern myotis