

LANDSCAPE ECOLOGICAL PLANNING: INTEGRATING LAND USE AND WILDLIFE  
CONSERVATION FOR BIOMASS CROPS<sup>1,2</sup>

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**MASTER**

## **Landscape Ecological Planning: Integrating Land Use and Wildlife Conservation for Biomass Crops.**

### **Abstract**

What do a mussel shoal, a zoo, and a biomass plantation have in common? Each can benefit from ecology-based landscape planning. This paper provides examples of landscape ecological planning from some diverse projects the author has worked on, and discusses how processes employed and lessons learned from these projects are being used to help answer questions about the effects of biomass plantings (hardwood tree crops and native grasses) on wildlife habitat. Biomass environmental research is being designed to assess how plantings of different acreage, composition and landscape context affect wildlife habitat value, and is addressing the cumulative effect on wildlife habitat of establishing multiple biomass plantations across the landscape. Through landscape ecological planning, answers gleaned from research can also help guide biomass planting site selection and harvest strategies to improve habitat for native wildlife species within the context of economically viable plantation management -- thereby integrating the needs of people with those of the environment.

### **Introduction**

The current process of protecting biodiversity on a species by species basis is, in general, not successful. More and more species in the United States and abroad have become rare, threatened or endangered despite efforts to protect them. This is partly because protection efforts chiefly focus on species that have already become rare. This process of protecting biodiversity stops short of addressing why the species have been pushed towards rarity. The current approach does not investigate the hard questions which could lead towards answers to help solve problems between resource use and biological conservation, and instead inadvertently restricts private actions that could potentially help solve these problems before more species become rare. The Endangered Species Act plays an important role in the protection of biological diversity. However, it is designed as a triage approach that, in effect, slows the erosion of diversity, but will never by itself stop its loss. The Act is simply not designed to stop species from becoming rare, just stop them from becoming extinct. It is not always successful in doing the latter because it is sometimes too late to save critically endangered species. There are some species recovery success stories nationally and globally, but worldwide the tide of loss is greater than that of success (Wilson 1992).

The slow evolution of my thoughts as I began investigating, designing and implementing nature reserves was to invert this process. Meaning, instead of only setting aside nature reserves -- areas where human resource use is essentially off limits -- I began thinking about ways to integrate human use and natural systems in complimentary ways. Can we find ways to change the way we use land to meet traditional economic needs, to also incorporate the needs of ecosystems and species, and thus help nature as we meet our immediate resource and monetary needs? Such a process may help us get out in front of the avalanche of

species loss and rarity. This approach could mean, ultimately, less land would be needed as a "preserve", and agriculture and industry would have more flexibility in the way it uses its (and the nation's) lands as long as it is simultaneously conserving or even restoring biological diversity on these same lands. Realistic long-term conservation will fully require a combination of reserves and lands appropriately integrating use and conservation. One approach towards this goal is landscape ecological planning.

The sometimes adversarial relationship between agriculture, industry and development, on the one hand, and biological conservation, on the other, can cause negative impacts to both sides if it is an all or nothing proposition. To illustrate, the Loxahatchie National Wildlife Refuge in southeastern Florida is an area of over 200 square miles where development is off limits. However, the Refuge is surrounded by intensive land uses that can and do impact the Refuge. Urban, suburban and agricultural development dominate the areas surrounding the Refuge. These land uses impact the hydrology and water quality of the entire area, and substantially reduce the environmental condition of the marshland Refuge. Simultaneously, the Loxahatchie Refuge is off limits to private land use that might fit with the nature of the Refuge's ecology and also meet human needs. Side by side, these two extremes of use (all or nothing) do not work well for either area ecosystems or area people.

These are challenging problems, and I do not have ready answers to them. However, I will describe in this paper some explorations I have worked on to help get at answers through landscape ecological planning. I will try also to show how this way of approaching human/environment systems can be employed to help find solutions to land use and conservation issues for biomass plantings to benefit both the grower and biological diversity. Below are short illustrations of two landscape ecological planning projects that I believe have relevant lessons for both research and planning of biomass plantings. After depicting these projects I will relate lessons and approaches from them to the prospects of biomass development.

### **Clinch River, Tennessee**

In 1993, I developed a strategic plan for The Nature Conservancy to guide conservation in the free-flowing section of the Clinch River watershed in Tennessee. This section of river above Norris Reservoir in northeastern Tennessee (Figure 1) contains more species of freshwater mussels than the entire European continent (Schiller, 1993). Twelve of these species are listed by the U.S. Fish & Wildlife Service as Threatened or Endangered (Table 1).

The area is rural and isolated from cities and jobs by steep ridges and winding roads; consequently, it's people are very poor (Loring pers. com. 1993; Strom pers. com. 1993; U.S. Bureau of the Census 1990). The only level land in the watershed is restricted to narrow valley bottoms very close to the Clinch River and its tributaries. Farming and most human activity besides forestry are concentrated in these valley bottoms. Small-scale tobacco, corn, pasture, hay, truck farming and subsistence gardens are the primary economic activities in

the area; this area also increasingly serves as a bedroom community for areas outside the watershed. The interaction between water and lands that are sometimes heavily and inappropriately used causes serious water quality and physical habitat degradation for mussels and some species of fish and snails in the river (Ahlstedt pers. com. 1993; Strom pers. com. 1993; Neves pers. com. 1993). Some of the endangered species known from recent years to live in the river may no longer be extant (Ahlstedt pers. com. 1993). River water quality, however, is in general better here than in some other rivers in the region because the area is so rural. This is why the mussels and other aquatic species still exist in high diversity and numbers as compared to the neighboring Powell River (Figure 1), which may have been degraded by coal mining related stresses from the Cumberland Mountains (Ahlstedt, pers. com. 1993). This diversity of mussels in the Clinch River is also threatened by other sources of stress beyond land uses, such as exotic species (zebra mussels, asiatic clams), gravel dredging at shoals, and chemical point and non-point pollution (Schiller 1993), including periodic spills at up-stream industry or on transportation lines that cross the river (Hobbs 1992).

The watershed is large, so The Nature Conservancy could not, and did not want to, buy up land that threatens the river's species and remove area inhabitants. What was needed was an approach to conservation that could be effective within the parameters of working farms and a rural populace continuing to inhabit the area. The Conservancy would have to work with individual landowners to find overlap of benefit for the landowners and aquatic species. In short, an effective conservation plan would have to carefully define the problems in the watershed that most critically threaten the mussels, and determine the specific causes of these problems at a sufficient level of detail to work directly with area residents to reduce the detrimental effects of certain actions, rather than attempting to restrict broad economic activities in the watershed. Activities such as agriculture are linked to mussel degradation in a general sense, but are activities of central benefit to area inhabitants. This level of detail is needed for any real integration of people and nature for mutual benefit, and in my opinion, is a central premise of effective landscape ecological planning.

This landscape ecological planning approach built from and added to a conservation plan developed by the Virginia Nature Conservancy (Hobbs 1992) for the Virginia portion of the Clinch watershed. To meet the objectives outlined above, the following describes how the strategic conservation plan for this large watershed was created.

Interviews were conducted with recognized experts on both the aquatic fauna of concern, and on the area and its people. This included experts from the Tennessee Valley Authority, the Natural Resource Conservation Service, the Tennessee Wildlife Resources Agency and Virginia Tech. I toured the watershed with several of these key experts, some of which have or do live in the watershed. From these interactions, we evaluated general types of stress to the river's most endangered groups of species (primarily mussels, but also several fish and snail species). These stress evaluations were based on the best available information and the educated opinions of the interviewees. In the stress evaluation, we assigned ratings of very high, high, medium and low to four aspects of each stress: 1) knowledge level of the

stress, 2) current threat from the stress, 3) potential threat within 10 years, and 4) the possibility of realizing the potential threat within 10 years (Table 2). Information and research needs for each stress were also laid out. Once this evaluation was completed, each stress was assigned a level of priority for which the stress would be addressed by The Nature Conservancy (very high, high, medium, low). This determined the most critical stresses to the river's aquatic fauna, pointed out information needs, and laid the groundwork for all future ecological planning across the watershed.

The next step was to determine the causes, or agents, of each stress in the upper Clinch (Hobbs 1992). Each expert was asked individually what they thought were the primary causes of each stress. Once I had a list of all causes mentioned, experts were given the entire list and individually asked to rank the causes of each stress in categories: very high, high, medium and low. Subsequently, I tallied and merged all of these responses into one list. Through this process, a stress analysis emerged that 1) ordered the stresses from highest to lowest priority (based on the stress evaluation process), and 2) determined and ranked the causes of each stress from highest to lowest priority (Table 3). Strategies were then developed to address each cause of stress in priority order (Appendix A). The strategies The Nature Conservancy are conducting first are those that address the highest ranked causes of the highest ranked stresses to the system. Some strategies are very specific, such as the following:

"Initiate land owner contact program in prioritized areas where stress agents have been identified."

"Divide pasture into compartments with fences, for subsequent livestock rotation."

"Reduce slope on bank that is undercutting and unstable, and plant trees/other vegetation to stabilize."

"Help create off-stream water sources for livestock."

"Identify chemicals used on transportation and utility corridors, lawns and parks, and their threat to aquatic organisms."

Other defined strategies are extremely general due to our level of knowledge as we began this process, such as:

"Work with researchers to understand and/or better define this agent of stress."

Combinations of strategies are directed at individual causes of stress, with outcomes from strategies implemented first helping guide which subsequent strategies are to be undertaken.

The above process provided a topical prioritization for The Nature Conservancy -- what to work on first, and how to begin. But the upper Clinch is a big watershed, and even with

prioritization of stresses and their causes, there still were too many places to begin knocking on doors without a thorough way of prioritizing where to begin to make the most conservation impact, and to stop system degradation in those areas that could most harm the Clinch's rare and diverse aquatic fauna. For example, identical causes of stress can impact the river's aquatic fauna differently depending on where they are located in relation to centers of rare aquatic fauna.

Mussels, and most of the other rare species in the river, are concentrated on shoals -- shallow areas of turbulent water underlain with gravel and rocks. Adult mussels anchor themselves in the rocks by a muscular foot and feed by filtering large amounts of water that spill over the rocky shoals. The filter feeding is part of the reason mussels are susceptible to water quality problems, because of the volume of water that passes through a mussel as it feeds. These shoals are discretely located in the river between pools of deeper and calmer water with loose sediment bottoms. Three shoals in particular -- Brooks Island, Kyles Ford and Wallens Bend (Figure 1) -- contain most of the river's rare species and have the highest populations of these species in the Tennessee portion of the watershed (Ahlstedt 1983). These three shoals were chosen by The Nature Conservancy and the team of experts as in need of greatest protection.

To first locate, and then address, the most critical causes of the highest priority stresses to the system, I developed a three-teired geographic prioritization centered on each of these three shoals. First, the stresses with similar vectors for impacting aquatic fauna were lumped into four categories. The four stress categories are: stresses related to 1) land uses, 2) exotic species, 3) point source pollution/chemicals, and 4) the need for education to change human behavior. Critical, primary and secondary geographic prioritization boundaries were developed for each category around each of the three most biologically significant shoals.

The critical boundary developed for each stress category corresponds with an area to protect the shoals over a 2 to 3 year time period and to stop "hemorrhaging" of the system. The primary boundary for each category corresponds to 10 to 20 years of protection to the shoals, and the secondary boundary for each corresponds to 100 or more years of protection. The Conservancy will eventually have to work on most all causes of stress in all four categories across their respective secondary boundaries to meet its long-range conservation goals for the watershed.

Physical boundaries for each category of stress are not absolute, but were agreed upon by interviewed experts as a meaningful way to prioritize areas to first investigate, and then to address those most important causes of highest priority stresses to the system that are found within each boundary. Overlaying a geographic prioritization for investigation onto a prioritized list of causes of top stresses to the system helped point The Nature Conservancy to particular areas to begin work, and on what to work.

This approach to landscape ecological planning was built on knowledge of the ecology of the species of concern, realities of the stresses to these species and their causes, and the realities

of implementing actions to address highest priority causes of stress in highest priority areas. Many of the causes of stress to aquatic fauna in the Clinch River are also damaging to the people of the area: soil erosion from over grazing, the loss of expensive chemicals washed from crops into streams, stream bank collapse and subsequent loss of farm land to the river, and chemical spills that make river water dangerous to use for swimming or fishing. Developing strategies to reduce these elements can have direct benefit to people in the area as well as help protect mussels and other aquatic fauna. Defining win-win solutions are key to making long-term improvements in the area's aquatic fauna and in the quality of life for the area's people.

This plan was designed to protect nature in the watershed without creating a nature reserve where people are excluded -- a vastly different approach than that of the Loxahatchie National Wildlife Refuge discussed above. With details of the approach developed, it will be several years before an evaluation of plan success can be made. Pragmatic adjustments will have to be made to the plan as lessons are learned. However, this way of approaching an integration of people and the environment holds promise for other systems. Instead of restricting people from engaging in certain economic activities like farming, this landscape ecological planning process uses the idea of "ecological performance zoning" to work with people to adjust specific actions that can impact the environment, while continuing to promote economically viable activities in the area.

### Central Florida Zoo

How does one build a 300 acre zoo on a site that supports two rare species -- one federally Endangered, the other of special concern in Florida? More importantly, how does one do it profitably while increasing the habitat and populations of both species? I worked with a team of planners, wildlife biologists and landscape architects to design a zoo on 400 acres of scrub habitat that supports gopher tortoises (Gopherus polyphemus) and scrub jays (Aphelocoma coerulescens) in Seminole County, Florida. The process required knowing the autecology of each rare species, where they are located on the site, what constitutes habitat for each, and what factors create and maintain habitat of maximum suitability for the species over time. This includes knowing how soils affect vegetation, the disturbance history of vegetation, including fire, and how management could create more habitat than currently exists at the site, while allowing a large zoo to coexist on the site.

We began planning the site by discussions with zoo personnel to learn their needs. These were many and diverse, including walkable distance, facility access and infrastructure locations. We then collected soils maps and descriptions for the county, USGS topographic maps that cover the site, and a true-color recent aerial photograph of the site at a scale of 1" = 400'. We could see every tree and shadow it cast with this true-color photo.

We began our listed species surveys by using standard techniques to assess scrub jay populations and locations. The approach was to define all habitat that could possibly support scrub jays at the site, and walk straight lines through all of this habitat with frequent

stops to play a tape of scrub jay territorial sounds and wait for scrub jays close-by to respond in typical territorial fashion for each family group's territory. We used a hip-chain to measure distances along our transects, and carefully estimated the locations of any scrub jays responding to the tape by relating their location to the aerial photograph. Population numbers were calculated, and scrub jay numbers and locations were mapped on an overlay for the aerial photograph (Figure 3).

We also used standard techniques to survey for gopher tortoises. We walked transects based on compass bearings in a "net" fashion across all areas that could possibly support gopher tortoises. All tortoise burrows sighted were recorded as active, inactive or abandoned. Individual tortoises sighted were also recorded. Area covered by transects was divided by total acreage of gopher tortoise habitat, and population estimates were made using Florida Game and Fresh Water Fish Commission calculation guidelines (Cox et al. 1987). Densities were determined individually for each habitat area of different character, and mapped on an overlay for the aerial photograph of the site (Figure 3).

Habitats across the site were spot investigated and characterized; soils were related to each habitat type. Then, habitats were mapped on an overlay for the aerial photograph. This provided us with a picture of the current state of the site -- the location, density and populations of rare species, the habitats that support them, and all other habitat types on the site.

But, everything in nature is in flux over time. Habitats change; species populations go up and down with or without people. We did literature reviews to determine the disturbance cycles of the habitat types currently on the site, and the ecology of the dominant vegetation of each habitat. Some of the habitats were purely of human origin. The area of highest gopher tortoise density and population, for example, was an old orange grove that had become a cherry tree savannah with non-closed canopies of the trees, continuous grassy understory, and unconsolidated sandy soil -- all excellent habitat elements for the gopher tortoise. A small dirt road leading from this area was also identified as prime gopher tortoise habitat.

Through this process, we determined that without human intervention the prime area for gopher tortoises would close canopy over time, shade out the grassy understory (which provides forage for the gopher tortoise), and significantly lose habitat value. The same is true for scrub jay habitat -- without periodic introduced fire, the site had grown in, and would continue to do so. Much of the site has the appropriate geology and soils to support habitat for scrub jays and gopher tortoises but does not currently do so because the habitat's natural disturbance cycle had been interrupted. Understanding this was an exercise in understanding links between physical and biological processes on site that create vegetation communities that change through time, and which are in turn perceived and used as habitat by certain wildlife species (Figure 4).

This told us that the "footprint" of the zoo could occupy prime existing habitat areas,



because with proper management the site could support habitat for both species in other areas away from the zoo. Furthermore, areas of transition between less intense zoo use and natural Florida scrub habitat could be maintained so that even within the footprint of the zoo, these rare species could live and thrive. Thus, areas to meet zoo needs could also directly meet rare species needs, if integrated properly. Fire management was targeted as a way to bring habitat quality back to many areas of the site that had become overgrown and had thus lost habitat value for the rare species. Fire breaks between areas to be managed would allow habitats to be managed in various stages of succession; fire breaks, like dirt roads, also provide gopher tortoise movement corridors and preferred burrowing locations. With these and other treatments, we discovered the site could support both a world-class zoo and increased habitat and populations for gopher tortoises and scrub jays (Figure 5).

What had begun as a "hands off" site due to the presence of rare species, became a workable site to meet development needs because we realized that what is on site now should not limit our thinking about what the area once was, what it would become without human intervention (less habitat), and what it could be with appropriate management (more habitat). Understanding the links between species, habitats and ecological changes through time, and zoo development needs, provided an opportunity to integrate land use and biological protection and restoration. When looked at in this light, the site provided opportunity to integrate the needs of people with those of nature, rather than restricting the former and degrading the latter.

### **Lessons and Applications for Biomass plantings**

Landscape ecological planning can also offer benefits for integrating biomass crops with wildlife conservation by helping to define and target needed research, and subsequently applying research findings via ecological performance design to meet economic, environmental and energy goals of the crops on agricultural lands. To do so, experts in ecology and wildlife biology need to work closely with farmers and industry, economists and power producers, at detailed levels to first define the problems and desired outcomes of meeting energy, profit and biodiversity objectives on the same lands. Second, research to address these questions must be defined and undertaken at the level of detail necessary for application of findings. Third, institutional constraints need to be mitigated to assist farmers and industrial growers in meeting multiple objectives, without inappropriate regulation that stymies such efforts.

Key aspects of the landscape ecological planning process discussed above that need to be applied to biomass research and development include: 1) site development problems must be viewed in adequate detail, 2) connections between ecological processes must be understood, and 3) an interdisciplinary team must work creatively to advance the needs of site development along with those of native species. To integrate biomass crops and wildlife conservation on agricultural lands, time must be considered: what we see on site now isn't how the site always was, or will be. Various scales are important: spatial patterns of habitat represent patterns of soils, disturbance and subsequent succession. Changes in habitats, and

their potential directions, must be understood. Species sense and react to vegetation as habitat, and beneficial habitat components can be incorporated into various land uses. Management of a site to meet human needs can improve or degrade a site's ecological functions, sometimes inadvertently, as was illustrated with the old orange grove that now is prime gopher tortoise habitat on the proposed site of the Central Florida Zoo. These and other ideas of ecological landscape planning hold promise for integrating biomass crops grown for profit with improvements in wildlife habitat on marginally productive crop lands in various regions of the U.S. (Table 4).

Within this general framework, we have identified some specific needs that are currently helping direct research to develop planting guidelines for biomass. For example, research is needed to understand how ecologically sensitive, rare, or otherwise significant wildlife species use biomass crops as habitat compared to probable alternative land uses (e.g., row crops and naturally regenerating forests). Some research is currently ongoing in this direction (Christian et al. 1994; Hoffman 1994). We need to understand how habitat value for such species changes through the planting, growth and harvest cycles of different biomass crops. Also, we need to know how different economically viable management strategies increase or reduce wildlife habitat value of these crops, and what impact or benefit such crops may have on adjacent natural habitats in various landscape contexts, and in different regions of the country. Importantly, we need to understand relationships between wildlife benefits from different biomass crop management strategies and crop productivity. Some of these questions are to be investigated beginning in the 1996 field season, and findings developed into practical guidelines to begin integrating biomass crop development and management with wildlife habitat improvement.

Protecting or restoring biological diversity while lands are reworked to meet human needs is a monumental challenge. To solve complicated questions of this scale will require more intensive investigations, creative designs, and team work than has generally been done in the past. Time and money investment necessary to integrate some land uses with certain ecosystems will rule out the practicality of integration. Such integrations are just not feasible, and some areas need to be set aside for conservation purposes so that entire systems are balanced appropriately. All ecological performance design processes involving landscape ecological planning will quite possibly require greater time and effort than typical site development processes. The rewards are greater land use flexibility, potentially less expensive development and mitigation processes, and conserved or protected biological diversity. For many land uses and ecosystems including biomass crops, I believe solutions will come in small steps, and farmers and growers can benefit immensely from greater land use flexibility, which should be a result of initiative and creativity on the part of the agricultural industry to help solve biological conservation problems that regulations to protect rare or endangered species cannot do alone.

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**Figure 1. Clinch Valley Bioreserve and primary shoals.**

**Table 1. Federally listed Threatened & Endangered Species in the Tennessee portion of the upper Clinch River.**

**Table 2. Sample from Stress Evaluation for the Clinch River.**

**Table 3. Sample from Stress Analysis for the Clinch River.**

**Figure 3. Rare species locations and jurisdictional wetlands at the proposed Central Florida Zoo site. (Red = rare species, yellow = wetlands).**

**Figure 4. Schematic relationship between species, communities, and physical & biological processes.**

**Figure 5. Schematic land use plan for rare species habitat and zoo footprint. Purple = zoo footprint. Green = potential habitat areas for gopher tortoises and scrub jays. Notice overlap of use in transition areas of less intense zoo use.**

**Table 4. Some landscape ecological planning concepts with relevance for biomass plantings.**

# APPENDIX A

## STRATEGIES TO ADDRESS AGENTS OF STRESS IN THE CLINCH SYSTEM

### A. DEFINE AND FULFILL TNC INFORMATION AND RESEARCH NEEDS

1. Discern the geographic component and character of this stress agent, with emphasis on areas related to centers of aquatic biodiversity
2. Investigate U.S. Navy experimental ship paint to reduce barnacle attachment, for possible application on boats to reduce accidental zebra mussel translocation. Continue search for other helpful technologies to reduce possibility of zebra mussel invasion
3. Gather mussel recruitment information collected from muskrat shell middens by Tennessee Tech
4. Identify and understand existing regulations affecting water quality
5. Conduct detailed agricultural use, land condition, point source and potential threat inventory, assessment and mapping project for the most critical areas of the Clinch and its sub-watersheds. Put on GIS. Make all data available in hard copies at local SCS office, agricultural extension office, R,C&D office, TWRA office, County Governments office, TVA Norris, and Tennessee Field Office of TNC. Use as the number 1 planning tool for the Conservancy and other organizations/agencies, and as a very comprehensive educational tool that can help farmers by assisting them in making informed decisions.
6. Investigate and define any problems with municipal waste water treatment, or solid waste disposal
7. Implement semi-structured interview with targeted individuals to assess community economic and social needs, knowledge level of the river, and interest in conserving the river and its biological components. Use this platform to learn what local community needs/values are to discern possible overlap in agendas, best way to work in the watershed by building a strong local constituency
8. Accurately define where agents of stress overlap and correspond with loss of money/time/productivity for landowners for the short term (less than 2 years), for the intermediate term (2-5 years), and for the long term (greater than 5 years).
9. Identify chemicals used on transportation and utility corridors, lawns and parks, and their threat to aquatic organisms.
10. Define best areas for mussel reintroduction
11. Define what education/inspection control programs are in place to address zebra mussels. Define who is responsible for these, and how TNC can help.
12. Investigate how to learn about this stress agent
13. Discern how we are going to address this stress agent

14. Work with Virginia TNC and VPI to define and/or reduce threat that is primarily centered in Virginia.
15. Work with researchers to understand and/or better define this agent of stress.

**B. STABILIZE RIPARIAN ZONE**

16. Riparian fencing
17. Reduce slope on bank that is undercutting and unstable, and plant trees/other vegetation to stabilize
18. Reestablish trees/vegetation in riparian zone
19. Prune toppling riparian trees to re-balance, reducing bank "pull-outs"

**C. CREATE AND/OR IMPROVE AGENCY AND ORGANIZATION PARTNER PRESENCE IN THE CONSERVATION PROJECT**

20. Thoroughly define cost-share partners for fencing and other BMP implementation actions
21. Increase funding available for cost sharing on BMPs (TDOA, USDA-SCS, TVA, EPA, others)
22. Work with the agriculture community and other agencies and organizations, to create helpful partnerships and define alternative strategies.

**D. IMPROVE AND/OR INITIATE BIOTIC AND ABIOTIC MONITORING PROGRAMS**

23. Investigate who is monitoring or has monitored water quality, flows, sediment loads, bank and bed erosion and aggradation, and aquatic biota; where they are monitoring or have monitored; when they are monitoring or did monitor; what methods they used or are using; and where the data are available.
24. Periodically monitor water quality (during storm events) on priority tributaries to Clinch, near their intersections with the Clinch, and on the Clinch itself in targeted locations
25. Monitor the Clinch at several key locations in an ongoing (continuous) program
26. Monitor biological components of the aquatic system in a manner effective at assessing trends, and helpful to understanding why a certain trend is witnessed
27. Help step up zebra mussel monitoring
28. Setup inspection program

**E. CREATE AND IMPLEMENT EFFECTIVE EDUCATIONAL PROGRAMS/ACTIVITIES**

29. Increase and improve zebra mussel education program
  - a. at all put in areas from Norris Dam upstream
  - b. to all landowners along the mainstream from Norris upstream

30. Provide education on existing regulations that can/do effect local landowners and land use
31. Provide education about the importance and uniqueness of the upper Clinch River's biological diversity.
32. Use information gleaned from #5 above to provide education to landowners about soils, land use, land carrying capacity, and alternative management and land use practices that can benefit the landowner; provide information on money, time and productivity losses to individual landowner(s), where losses are associated with agents of stress to the aquatic system
33. Provide education about clearing streambank vegetation, and subsequent increased bank erosion (slides/pictures over time showing one place with a vegetated bank and one without, and differences in loss of land to the river)
34. Provide BMP education for timbering and construction operations

**F. IMPLEMENT BMP'S TO IMPROVE PASTURE/ROW CROP MANAGEMENT, WHILE RETAINING CURRENT LANDOWNER.**

35. Increase mulch/cover crop use on tilled lands
36. Reduce number of livestock per unit area on overly used pasture (without increasing livestock use of wetlands or riparian zones)
37. Help create off-stream water sources for livestock
38. Divide pasture into compartments with fences, for subsequent livestock rotation
39. Help convert intensive agricultural land use, while retaining current owner. (Convert to hunting, hay, etc.)

**G. IDENTIFY AND WORK WITH KEY LANDOWNERS AND COMMUNITY LEADERS, FOCUSING ON AREAS WHERE AGENTS OF STRESS ARE GEOGRAPHICALLY DEFINED**

40. Initiate LOC program in prioritized areas where stress agents have been identified.
41. Identify potential demonstration farmers in critical areas, make contact.
42. Get local leaders interested and involved in our agenda - to reduce barriers and promote positive community action.
43. Work carefully to create helpful partnerships in the area with local individuals

**H. ACTIVELY MANAGE CRITICAL SPECIES, INCLUDING PREDATION/ COMPETITION INTERACTIONS THAT CAN IMPACT CRITICAL SPECIES**

44. Reintroduce selected mussel species to appropriate areas
45. Trap muskrats, raccoon and/or other targeted mussel predators, as a controlled research project

I. WORK DIRECTLY WITH LOCAL INDUSTRIES, MUNICIPALITIES, MINING CONCERNS, TRANSPORTERS AND TRANSPORTATION AGENCIES (TDOT, VDOT) TO REDUCE POINT SOURCE DISCHARGES AND POTENTIAL TOXIC SPILLS AND OTHER TRANSPORTATION AND INDUSTRY RELATED AGENTS OF STRESS

46. Identify planned transportation projects that may directly or indirectly impact the area's aquatic species
47. Improve municipal waste management
48. Reduce chance of accidental toxic discharge from industries, and assure that regulations are being met.
49. Reduce chance of accidental toxic spills from transportation routes
50. Reduce the use of chemicals on transportation and utility corridors that are harmful to aquatic organisms
51. Reduce AML impacts
52. Reduce current coal mining impacts
53. Develop efficient household solid waste collection program.

J. SECURE LEGAL INTEREST IN PRIORITY LANDS

54. Buy farm, and lease back to be farmed, with BMP restrictions
55. Lease farm and use for a less damaging purpose (regrow vegetation; hay harvest only; quail hunting; less head of cattle/livestock)
56. Buy land, restore it to natural (or nearer to natural) cover (to reduce erosion/nutrient loading)
57. Investigate possible conservation easement opportunity on targeted lands.

K. IMPROVE REGULATORY & ZONING ENVIRONMENT, AND ENFORCEMENT

58. Make sure industry discharges meet all appropriate regulations
59. Increase enforcement of existing regulations
60. Improve existing regulations
61. Create enforceable specifications for boat ramp construction/boat access points in the watershed
62. Create zoning changes requiring streambank vegetation integrity, reducing channelization and re-channelization activities, and restricting livestock access to streams, especially in critical areas