Southern Plains Inventory and Monitoring Network
Report from the Aquatic and Landscape Workshop
August 9-10, 2005
Hosted by Fort Union National Monument at
Highlands University, Las Vegas, New Mexico

OVERVIEW

This two-day workshop was part of the process to develop a long-term ecological monitoring program for natural resources in the Southern Plains Inventory and Monitoring Network (SOPN). Developing conceptual models is one of the first steps towards selecting a suite of efficient and cost-effective indicators ("vital signs") of ecological integrity. During the first day draft versions of the aquatic conceptual models were presented by Sue Braumiller and landscape models were presented by Todd Swannack. These models were given a thorough review by workshop participants. The second day used the previous day's discussion of conceptual models as a framework to develop a list of potential aquatic and landscape vital signs for SOPN. The workshop was attended by 37 people, including 17 outside experts and at least one representative from all 11 SOPN parks (Table 1).

OBJECTIVES

1) Review aquatic and landscape conceptual models. Provide model developer with suggestions for modifications and possible additional models.
2) Review the important natural resources and stressors of the network.
3) Develop/review list of potential vital signs with preliminary justification statements and monitoring objectives.

CONCEPTUAL MODEL REVIEW

Dusty Perkins started the day with an introductory talk on the Inventory and Monitoring Program and the Southern Plains Network. This was followed by the presentation of landscape and aquatic models by Todd Swannack and Sue Braumiller, respectively (See Appendix 1 for figures of the models presented). Then, workshop participants were divided up into rivers and streams (facilitated by Sue Braumiller), reservoir (Facilitated by Cathie Jean) and landscape (facilitated by Andy Hubbard) breakout groups. Each group was assigned the task of reviewing the models pertinent to their breakout group.

Conceptual Model Summary and Future Directions

This section summarizes the major comments and concerns of each breakout group and provides an outline of revisions to the existing models. Listed first under the "*Future Directions*" heading are the comments that were consensus among the groups and these comments will be incorporated into the revised models. Listed under "*Additional Comments*" are points of contention within the group or comments that were written on the model posters that were not discussed in the breakout group. SOPN staff will work with the model developers and the Technical Committee to determine which of the additional comments should be incorporated into the models.

Future Directions for Landscape Models:

1.) Landscape Pattern Model – The group came to consensus on a few changes to the presented model (Figure 1). The first change being that all of the arrows should be changed to double-sided arrows. The justification being that natural processes also alter human processes and landscape pattern can affect natural processes and human disturbances. Secondly, landscape pattern should also be an oval making it at the same level as the processes and disturbance ovals. It was also suggested that "Human Disturbance" be changed to "Human Processes".
2.) Development Effects Model – The group agreed to simplify this model by just having the major processes on the top line and the major stressors on the bottom line (Figure 2). All stressor ovals except for "Fragmentation" and "Disturbance Regime" should be dropped.

A fourth box, “management” was added to the processes line. The two major stressors identified in the bottom line would then be further developed into submodels.

3.) Natural disturbance regime model – No consensus for any changes.
4.) Altered Natural Disturbance Regime – The group suggested a revised model (Figure 3). The group thought that the original model was only a fire and grazing disturbance model. The new model incorporates climate and catastrophic events. More details will be added.
5.) Decrease In Unique Habitat –It was suggested that this model be dropped. If this model was to stay the definitions of unique and habitat need to be more clearly defined. In addition the submodel seemed to be too focused on birds, the migratory bird component should be dropped.
6.) Fragmentation – A revised model was developed (Figure 4). “Decrease” and “increase” should be changes to “changes”. Rename the model to “Habitat Arrangement” or “Habitat Change”. More details will be added to the revised model. It was also mentioned that abandoned lands were a major issue for the prairie landscapes. Land abandonment was more of an issue than urbanization.
7.) Based on the conceptual model discussion, the group then came up with a list of potential vital signs for landscapes (Table 2) to use in the next day’s discussion.

Additional Comments for Landscape Models

1.) Landscape Pattern Model – It was suggested to change the name to “Landscape Pattern Process”. Long term dynamics in monitoring should be noted on the model.
2.) Development Effects Model – There was concern that the model did not have exotic animals and exotic plants emphasized enough. Exotic animals should be tied to land use. Climate change and disease transmission was also suggested as a potential process.
3.) Natural Disturbance Regime Model – Some disturbances can lead to increase in biomass. This model as presented is really more for fire processes. Some disturbances can increase diversity.
4.) Altered Natural Disturbance Regime Model – Some members wanted to more clearly define the temporal and spatial scale of the model. It was also noted that the temporal scale for each park varied widely and that some parks are managing for certain periods of significance relative to the parks mission.
5.) Decrease In Unique Habitat – Change “unique” to “important”. Change “decrease” to “change” or “loss of”. Clarify whether “Source populations” refers to a park as the source or as in an ecological sense, survival outweighs mortality rates.
6.) Fragmentation – Is this referring to the park or as a landscape as a whole, specify. Need to clarify what is meant by “edge” can mean two natural habitats or natural versus agriculture/urban.
7.) There were extensive discussions about feedlots and similar concentrated agricultural issues for the prairie landscape and how this issue should be factored into the models.

Future Directions for Rivers and Streams Models

1.) There was a general consensus that the river and stream models should be re-done in a fashion that fit prairie streams better. The group proposed several changes to the overarching model and suggested that three new sub-models be developed.
2.) Overarching stream model – This model has been revised (Figure 4) and many components were collapsed into each other.
    a. Disturbance and stream characteristics ovals were eliminated because they are intrinsically included in other parts of the diagram.
    b. “Changes in Stream Flow Regime” was changed to “Stream Flow Regime”.
    c. “Water quality” was renamed “water chemistry”.
3.) Need to better define scales of models.
    a. Issues have a wider scope than just within the park boundaries….for example, some of the issues may involve the entire watershed.
    b. It’s important to look at upstream land-use, upland watershed characteristics.

c. Management really affects the whole system (e.g., removing intrusive vegetation from the stream may facilitate "drying up" of stream).

4.) The group thought there should be three main submodels for abiotic factors beneath the stream model. They are Stream Flow Regime, Stream Geomophology, and Water Chemistry. Brief sketches are shown in Figures 5, 6, and 7. Additional details will be added to the revised models.

5.) Riparian Model - Amphibians and reptiles can form a link between aquatic and terrestrial ecosystems – they're missing from riparian models

Additional Comments for Rivers and Streams Models

1.) Need to differentiate between what is stream and what is riparian area.
2.) Stream model – should this include services that streams provide? i.e. recharge?. Include a water physical attributes octagon.
3.) Potential vital sign - shifts in aquatic biota will reflect the factors (biotic/abiotic) affecting the stream/river assemblage in general.
4.) Need to consider fragmentation of riverine habitat.
5.) Streams are defined partially by their disturbance regimes. Floods are disturbances, which are not always bad – separate anthropogenic and natural.
6.) Water chemistry parameters (in addition to those listed on Figure 7) that could be measured at specific parks would be nitrogen, phosphorous, metals, bacteria levels, and protozoans.

Future Directions for Reservoir Models

1.) The lake model was very busy and could be simplified by emphasizing the dominant pathways.
2.) Lake Model
    a. Geology and time – These operate at much longer time range then a reservoir. Lake Meredith life is expected to be 100 years. Geology and time may be drivers for other natural ecosystems but for reservoirs it is in the background, might be better placed as such.
    b. Rename "Lake" model as "Reservoir Model". All lakes in SOPN are manmade. Hydrology of reservoirs is very different from lakes. Reservoirs have a disproportionate amount of drainage compared to natural lakes, and are therefore more influenced by watersheds. Benefits of reservoirs are artificial, not natural (recreation, drinking water).
    c. This model should be specific for the three parks in SOPN with reservoir systems.
    d. Lake morphometry and lake habitat characteristics should be joined in a single box.
    e. Siltation should be incorporated into model.
    f. When considering watershed effects, think conservation pool at LAMR. The pool has never been reached due to upstream diversions of water. Major effects on the amount of riverine, wetland, lake habitat.
3.) Water quality is the primary issue for LAMR, CHIC, and LYJO.
4.) Should develop tamarisk submodel. Factors to consider in the tamarisk submodel. LAMR is saline and tamarisk contributes to that. Tamarisk uses more water than it puts back, cottonwood doesn't. Need to recognize that reservoirs are multiple use. For example they could raise water level and flood tamarisk to control it. However, NPS does not control the water level, and biological reasons are a low priority – leaving water in rivers is not considered useful by BOR or by water law.
5.) Submodel for salinity - Show tamarisk and it's effects. Currently the water from LAMR must be diluted with 75% ground water to reduce the salinity to make it suitable for drinking. Remove tamarisk, get more water that will then get allocated. Lowered water levels can expose areas and increase erosion – which can increase salinity. Increased evaporation, increased salinity.

6.) Eastern red cedar (CHIC) and juniper (CHIC and LAMR) should be considered in the main model or a submodel. They are native invasives that use a lot of water.
7.) The models could benefit form a consistent method of classifying the different types of habitat that are being evaluated. For example, the term aquatic habitat refers to areas that are permanently inundated with standing or flowing water. That would leave out other types of wetlands. It was recommended the application of the U.S. Fish and Wildlife service wetland classification system Classification of Wetlands and Deepwater Habitats of the US (http://www.npwrc.usgs.gov/resource/1998/classwet/lacustri.htm) as the criteria for defining the limits of the different wetland and aquatic habitats. This system has been formally adopted by the Secretary of Interior in Director's Order 77-1. Riparian habitats are critical and they are not defined by this classification system, so the character and limits of riparian habitats would have to be adopted from the literature.
8.) This group agreed that the limits of the reservoir group were the edges of the legally defined water level in the reservoir. This did not include any lacustrine emergent or submergent vegetation zones. As a result, the edges of the large lake systems were excluded and the list of vital signs pertains only to the open water areas (Table 3).

Additional Comments for Reservoir Models

1.) Where does water level management fall in the model? Under disturbance regime? Water levels are critical with how a lake acts. Should call it a disturbance regime, it's an artificial source.
2.) Discussion about herbicide use. Should that be incorporated into model?
3.) Add a box for political influence (allows uses which can increase erosion).
4.) Alternative model for reservoirs could be a bathtub model. Reservoirs have three basic subsystems: riverine, transitional areas, and main basin. Each should be modeled differently. For habitat, riverine areas and the transition from flowing to lentic are different then the main basin characteristics. Reservoir habitat is a result of lake morphology and changes with lake level. These submodels should be separated into riverine and reservoir habitats by the hydrology of the lake and the Cowardin classification system. A lacustrine system must be 2 meters at the driest area.
5.) Lake habitat has a central role in current model, maybe should be changed. Reservoirs are managed for sport fishing, not ecological values, therefore, lake habitat isn't as important in the model. Legislation at LAMR mandates that recreation is secondary to drinking water for panhandle communities. Presents a dilemma with the NPS mission to preserve. NPS Mission may be driving why the habitat characteristics octagon is central to the model.
6.) Watershed and riparian characteristics could be pulled out and placed into an ecotone submodel. Changes can be made to watershed and riparian elements that affect the system. Can't manage geology, time, landform, can watch climatic and atmospheric conditions.
7.) Reservoir depth affects water quality, they should be connected with an arrow.

AQUATIC AND LANDSCAPE ISSUES AND VITAL SIGNS

During the second day, the workshop divided into the same three working groups as the day before, reservoirs, rivers and streams, and landscapes. The goal was to review our Access database that contained issues that individual parks had raised during the 2004 scoping sessions and those that surfaced during literature reviews. Issues reviewed at this workshop pertained to aquatic systems and landscape level dynamics. Each group ranked all of the issues as high, medium, low, or not an issue (Tables 4, 5). Each group also reviewed and revised the possible vital signs, monitoring objectives and justification statements for each issue. Each group had the opportunity to add new issues and a total of seven new issues were added.

In ranking each issue the breakout groups were given the following guidelines, an issue would only be ranked high or low if there was consensus among the group that it was high or low. This method resulted in a list of high priority issues that were most important across the entire network. Issues that were high priority to one park, but not highly ranked across the network,

were captured by the individual park's ranking that occurred prior to the workshop. All issues that both groups ranked as low were dropped from future consideration as potential vital signs. All non-consensus issues were ranked medium. A fourth category, "not an issue" was created for issues that were important but could not be monitored in a meaningful way or did not fit the guidance for the inventory and monitoring program. Four issues were ranked low or not an issue and will be dropped from further consideration as a potential vital sign.

Each group had a list of issues that pertained to the breakout group. Some issues were reviewed by two or three groups, while some pertained to all three groups. When the groups had the same issues to review, their rankings were generally the same (Tables 4, 5). For example, all three groups ranked exotic plants as high.

At the conclusion of the workshop, a list of 47 issues related to aquatic ecosystems and landscape dynamics was developed (Tables 4, 5). In January, SOPN held a similar workshop for grassland systems. In fiscal year 2006, SOPN will evaluate the list of issues and vital signs developed at these workshops and prioritize, and then select the vital signs that will make up the monitoring program.

Landscape Group

The landscape groups examined 18 existing issues and added three new issues. They ranked weather patterns, exotic plants, woody invasive species, viewshed, and fire and fuel dynamics as high. Ozone was ranked low, and boundary survey and fencing and pollution from non-park sources were ranked not an issue. The former due to lack of reliable monitoring methods for ozone effects and the latter because the group felt it was a management issue, not a science/monitoring issue.

The group combined four issues pertaining to land cover (landscape pattern, land cover and land use, land condition, and connectivity) into one issue called landscape dynamics. The group ranked landscape dynamics as high. The group added native biotic populations and communities (ranked high) and petroleum and mineral exploration and extraction (ranked medium) as new issues. They justified the first category by saying that each park had individual species or groups that were listed as important and if you combined them across the network this category would rank high. The group proposed redoing the inventories periodically to determine the status and trend of focal species. The second issues pertaining to petroleum and minerals was justified because many of the parks do not own the mineral rights beneath the surface. If not done carefully this could affect both cultural and biological park values.

Reservoir Group

The reservoir group examined 27 issues. They ranked lacustrine community, exotic plants, erosion, groundwater levels, water quality, and e. coli levels as high. The southwestern willow flycatcher was not known to be breeding in the area of SOPN parks and was ranked low. Zebra mussels, Arkansas darters, and mineral, oil, and gas extraction were all ranked low. The group did not add any additional issues to the database. Within water quality the group said that some parameter that could be included that are not listed are salinity, chlorophyll A, anions and cations, hydrocarbons, and discharge rates. However, the group did note that there has not been an inventory or search for spring-related ground water fauna. If a search was done and rare species were found, then this might be something to consider as a vital sign.

Rivers and Streams Group

The rivers and streams group examined 28 issues and added 4 new issues. They ranked Arkansas river shiners, cottonwood riparian community, riverine community, upland springs, zebra mussels, exotic plants, erosion, groundwater levels, water quality, and water quantity as high. They ranked southwestern willow flycatcher and marsh rice rat as low.

The group added invasive native fauna, aquatic exotic species, soil health, and riparian communities. Aquatic and exotic species and riparian communities were both ranked as high. There was debate within the group that these two new issues might be redundant with exotic plants and cottonwood riparian community, but the group ultimately decided that they should be stand-alone issues to ensure their inclusion. For the new riparian community issue, some thought this was inclusive enough to include cottonwood and bottomland hardwood forest

communities, then what would be measured at each park would be determined by the particular type of riparian community present. Others thought that the cottonwood community was significant enough to be included as its own separate issue. Aquatic invasive plants were added due to the large impact these species can have on native systems. Early detection of these species can be an indicator of ecosystem changes that could follow. Riparian areas were added because they are limited in extent, but are often areas of high species diversity. Invasive native fauna and soil health were both ranked as medium. Invasive native fauna were added because anthropogenic modifications to ecosystems may allow some species to become over-abundant. These species can serve as an indicator of anthropogenic modification. Soil health was added because it can impact the long-term health and sustainability of the native plant communities and increase the ecosystem's susceptibility to plant invasions.

Figure 1. Revised landscape pattern model.

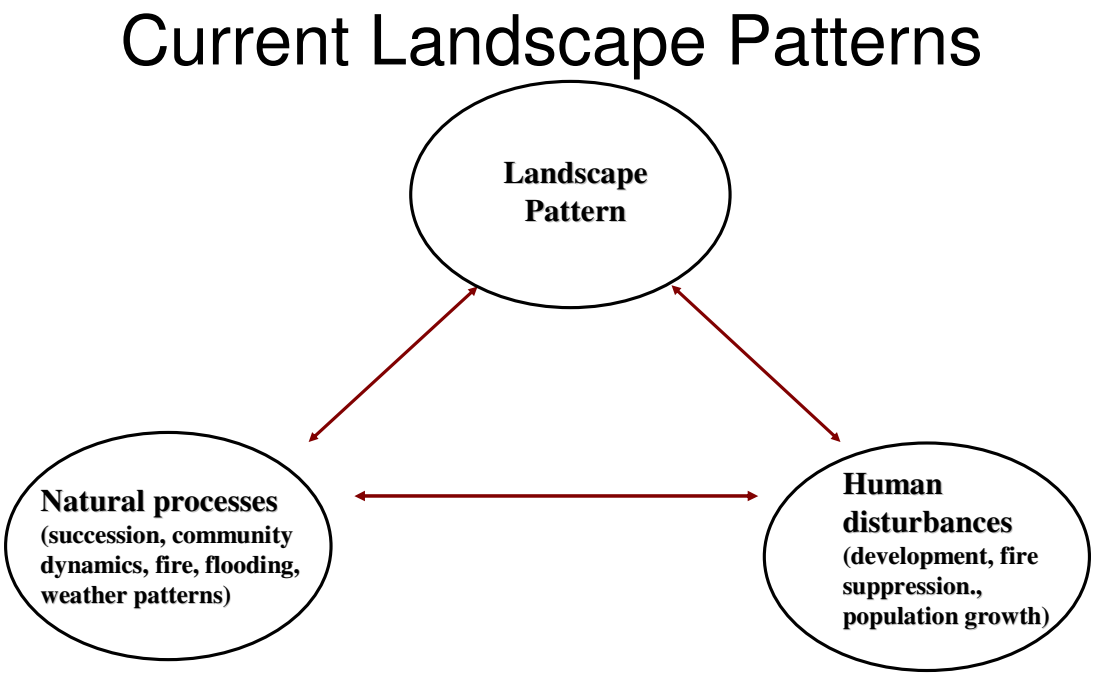

Figure 2. Revised development effects model

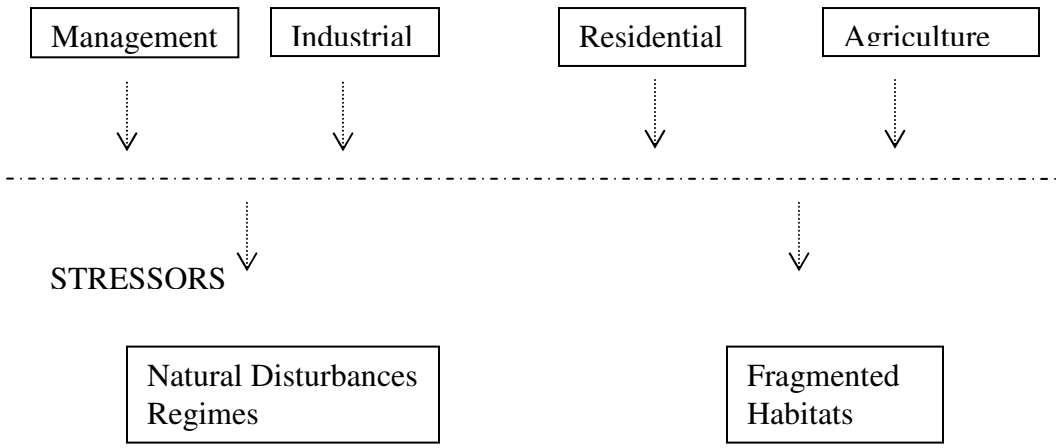

Figure 3. Revised altered natural disturbance regime model.

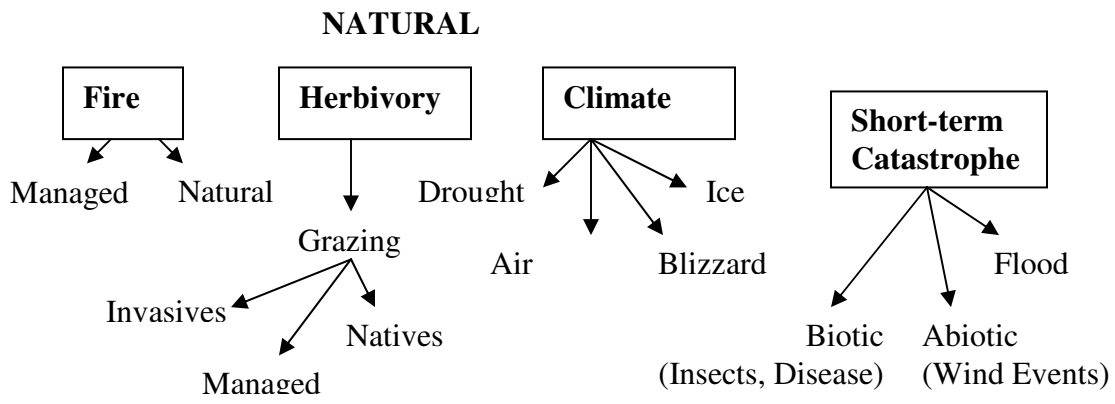

Figure 4. Revised fragmentation model.

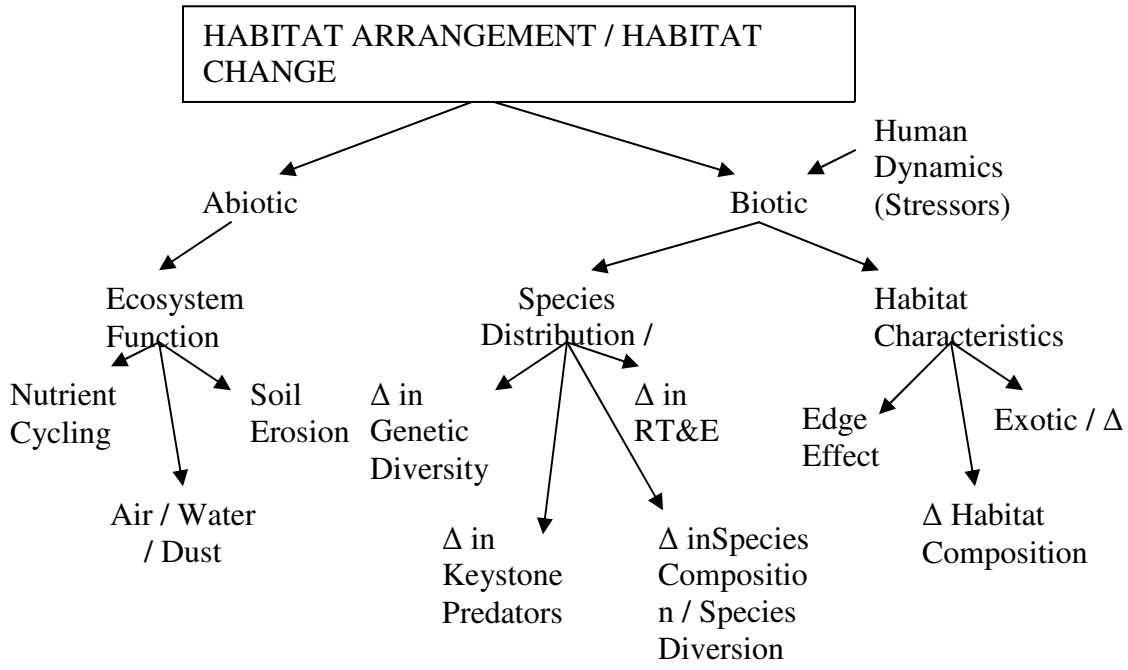

Figure 4. Revised overarching stream model.

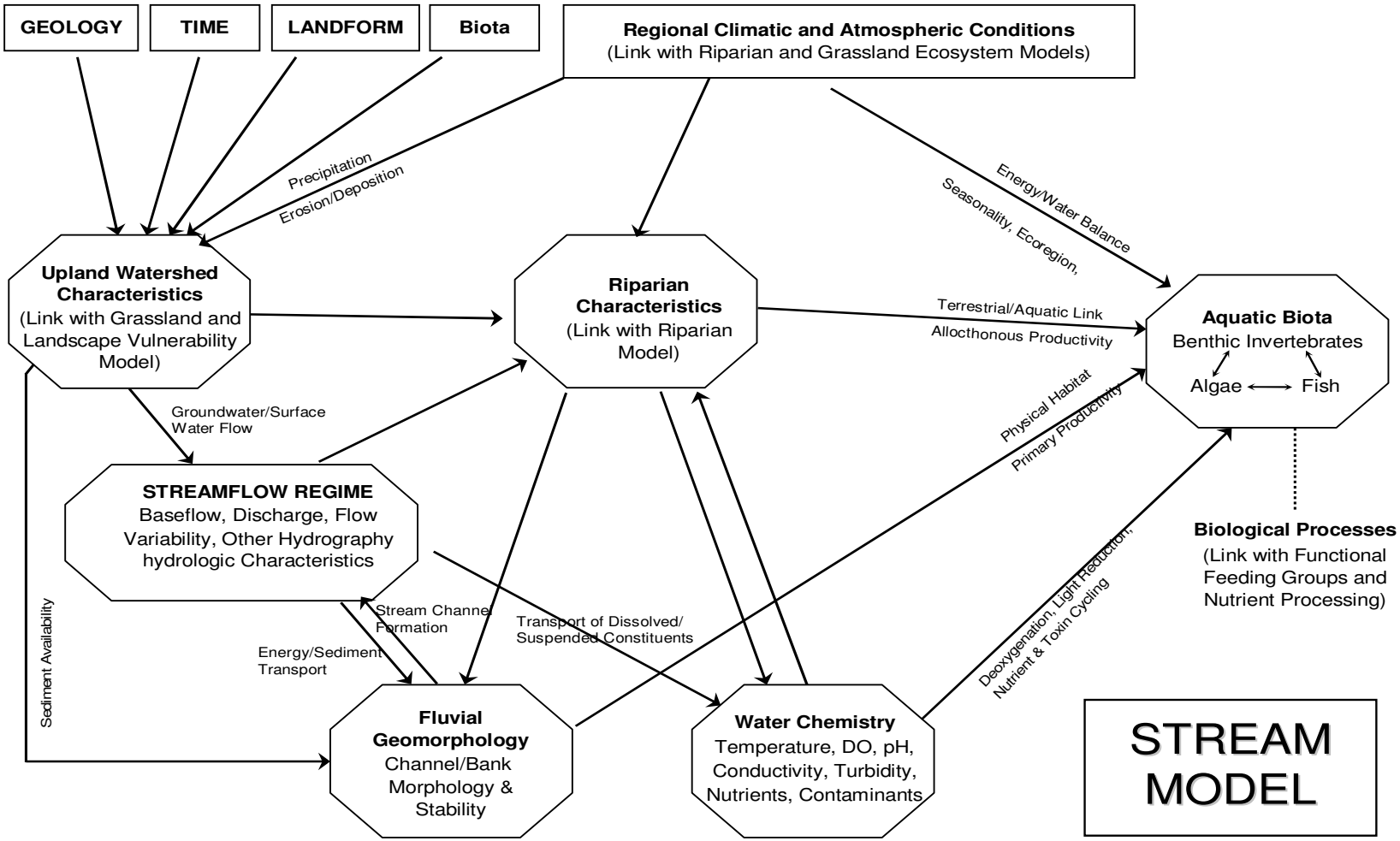

Figure 5. Streamflow regime submodel.

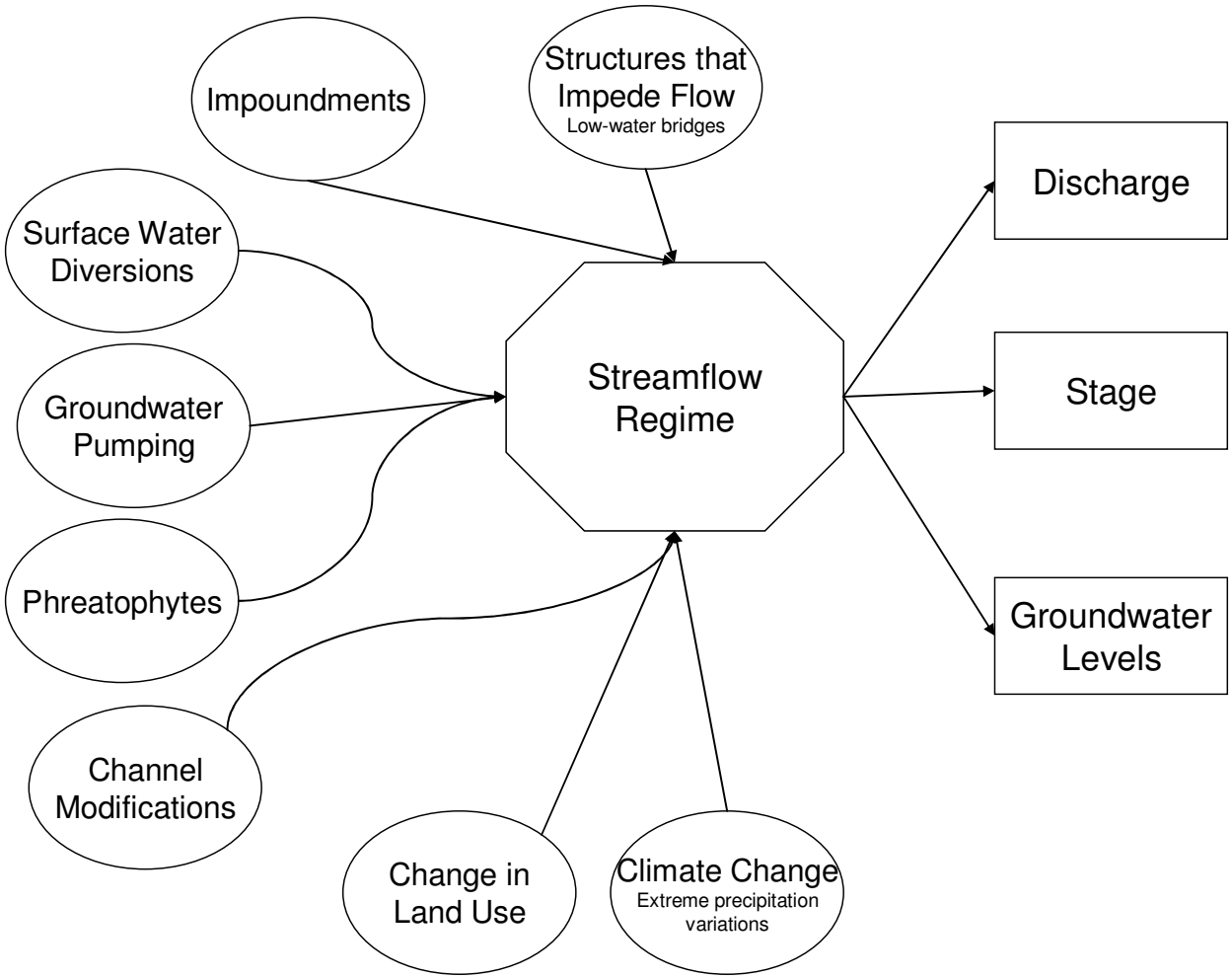

Figure 6. Stream geomorphology submodel.

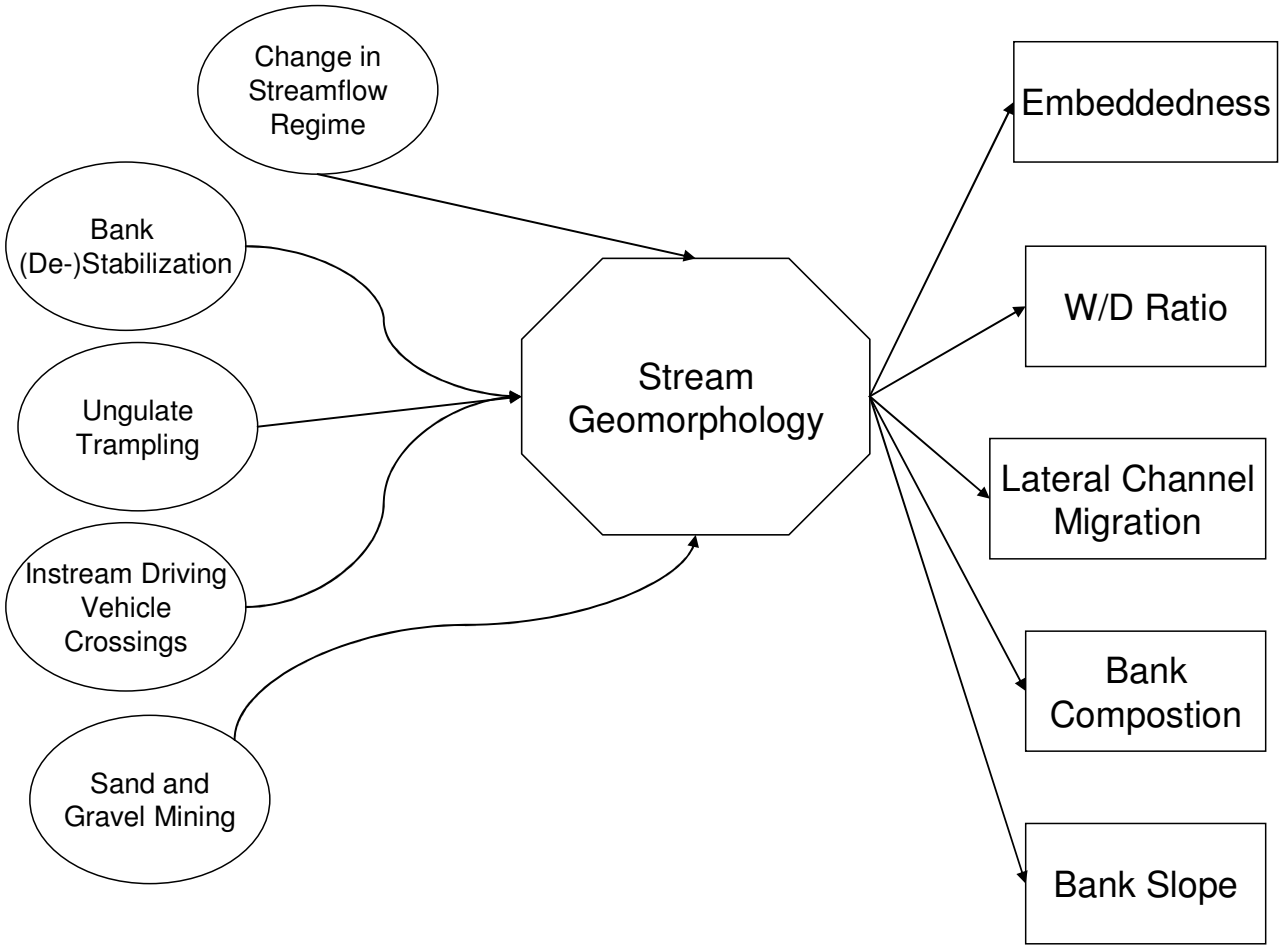

Figure 7. Water chemistry characteristics submodel.

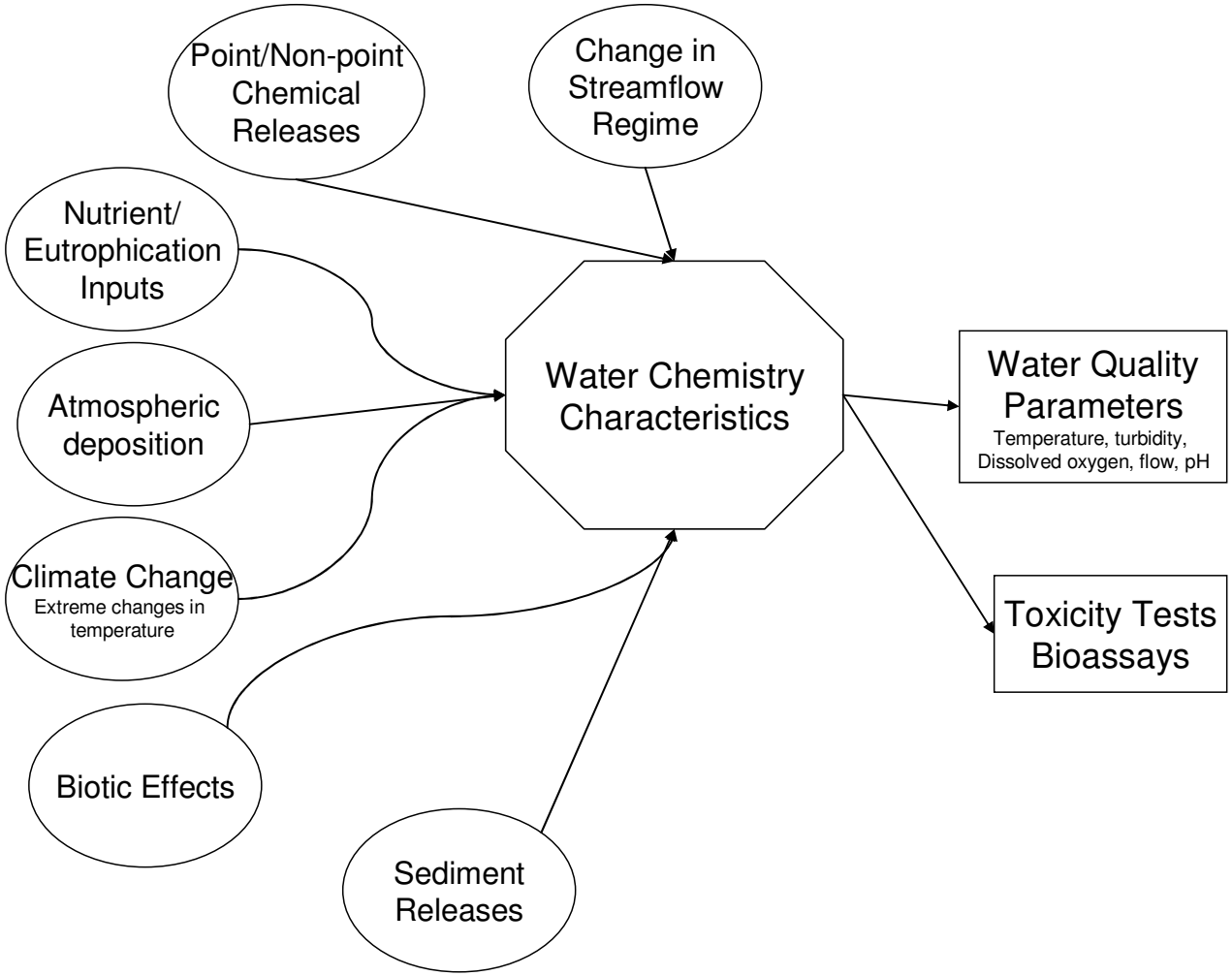

Table 1. Final Participant List

NPS Park Staff			
Person	*Position*	*Park*	*Breakout Session*
Ruben Andrade	Supervisory Park Ranger	Fort Union National Monument	
Steve Burrough	Chief of Resource Management	Chickasaw National Recreation Area	Reservoirs
Karren Brown	Superintendent	Lake Meredith National Recreation Area / Alibates Flint Quarries National Monument	Reservoirs
Dennis Ditmanson	Superintendent	Pecos National Historical Park	
Paul Eubank	Natural Resource Specialist	Lake Meredith National Recreation Area / Alibates Flint Quarries National Monument	Reservoirs
Jason Lott	Integrated Resource Specialist	Lyndon B. Johnson National Historical Park	Reservoirs
Alden Miller	Chief of Resources + Facilities	Washita Battlefield National Historic Site	Rivers
Fran Pannebaker	Natural Resource Specialist	Bent's Old Fort National Historic Site	Rivers
Maggie Johnston	Superintendent	Capulin Volcano National Monument	Landscape
Arlene Wimer	Natural Resource Specialist	Lake Meredith National Recreation Area / Alibates Flint Quarries National Monument	Rivers
Tony Cyphers	Park Ranger	Fort Larned National Historic Site	Rivers
Ted Benson	Park Ranger	Pecos National Historical Park	Rivers
Felix Revello	Chief Ranger	Fort Larned National Historic Site	Landscape
NPS Inventory and Monitoring Staff			
Person	*Position*	*Location*	*Breakout Session*
Dusty Perkins	SOPN Network Coordinator	Lyndon B. Johnson National Historical Park	Floater
Heidi Sosinski	SOPN Data Manager	Lyndon B. Johnson National Historical Park	Reservoirs
Tulia De Fex	SOPN Ph.D. Student	Texas A+M University	Landscape
Todd Swannack	SOPN Ph.D. Student	Texas A+M University	Landscape
Tomye Zettner	SOPN Graduate Student	Texas A+M University	Landscape
Karie Cherwin	SOPN Research Associate	University of Colorado	Rivers
Subject-Matter Experts – Preliminary List			
Person	*Organization*	*Expertise*	*Breakout Session*
Sue Braumiller	NPS	Hydrology, aquatic model developer	Rivers
Cathie Jean	NPS GRYN I+M Network	Network Coordinator	Reservoirs

Andy Hubbard	NPS SODN I+M Network	Network Coordinator	Landscape
Joseph Bidwell	Oklahoma State University	Toxicology, amphibians, invertebrates	Rivers
Kevin Noon	National Park Service	Wetland Ecology	Reservoirs
Tim O'Connell	Oklahoma State University	Landscape Ecology, birds, indicators	Landscape
Kathy Tonnessen	NPS – Rocky Mountain Cooperative Ecosystems Studies Unit	Air Quality	Landscape
Gillian Bowser	NPS- Gulf Coast Cooperative Ecosystems Studies Unit	Genetics, vertebrate landscape ecology	Landscape
Tim Bonner	Texas State University	Fish, stream ecology	Rivers
Carol Becker	USGS – Oklahoma City	Hydrology, Groundwater	Rivers
Bill Fisher	Oklahoma State University	Fish, stream ecology	Rivers
Keith Duncan	New Mexico State University	Exotic plants, vegetation	Rivers
Joanna Curran	Texas State University	Dam management, fluvial geomorphology	Reservoirs
Don Huggins	University of Kansas	Aquatic ecology, entomology	Reservoirs
Roel Lopez	Texas A+M	Wildlife Ecology, GPS, GIS	Landscape
Glen Longley	Texas State	Edwards Aquifer Water Quality	Reservoirs
Lisa Jameson	NPS - Gulf Coast Exotic Plant Management Team	Exotic plants	Rivers
Gary Willson	NPS – Great Plains Cooperative Ecosystems Studies Unit	Grasslands, fire	Landscape

Table 2. Potential landscape vital signs that were derived from the conceptual model discussion in the landscape group.

LANDSCAPE DYNAMICS
(Things remotely sensed)

- Land use/land cover
- Road density
- Impervious cover
- Percentage of exotic vs. native plant cover
- Mosaic of natural areas (patch size & arrangement)
- House density
- Percentage wetland cover
- Disturbed/undisturbed lands
- Land use change
- Connectivity on an eco-region scale
- Fences
- Corridors
- Utilities & ROWs
- Vegetation change
- Percentage of Riparian exotics
- Landscape fuel characteristics
- Measurement of grazing pressures in region
- Oil & mineral exploration

DEMOGRAPHIC DATA
(things gathered from records)

- Human population density outside of park
- Land ownership patterns
- Visitor experience / Economic impact
- Traffic volume (numbers, patterns)
- Land value/zoning

BIOTIC – FIELD BASED

- General avian community indicators
- Exotic plants
- Feral/exotic animals
- Wildlife diseases
- Change in species diversity
- RT&E species
- Large scale herp declines
- Invertebrates
- Regional bird pop trends from Breeding Bird Surveys
- Reproductive success of focal species
- Small mammal communities
- Grazing invertebrates

ABIOTIC

- Soundscape / nightsky / viewshed
- Erosion index
- Extreme climate events
- Soil budget – inflow/outflow
- Nutrient / Carbon cycling

- Ozone levels
- Nitrogen/Sulphur deposition
- Visibility

Table 3. Potential reservoir vital signs that were derived from the conceptual model discussion in the reservoir group.

- Water quality should be a vital sign at LAMR, CHIC, and LYJO. Dissolved oxygen, pH, conductivity, temperature, and measure of flow. All can vary diurnally, have to insure to consistency with time and season sample is taken. As we move to monitoring there are already some people monitoring water quality parameters at these parks, see what we can use and maybe find a way to get them to monitor an additional parameter we can use, but they aren't currently collecting.
- Lake level: determine by comparing inflow and outflow. Siltation can affect lake levels, need to incorporate ace siltation scale. Lake level is currently recorded at LAMR.
- Total N and total P measurements.
- Contaminants - Mercury in fish tissue at LAMR. Measure in biota (more consistent than in water, state also does). Mercury is the parameter that causes LAMR to be listed as 303(d) impaired water body. Contaminants may be park specific.
- E.coli levels.
- Whatever the herbicide is that is being used for tamarisk control.
- Hydrocarbons
- Testing rain water quality separately, source of problem? There is some depositional monitoring currently occurring, but they are few and far between and generally located near cities.
- Turbidity with secchi disk.
- Amount of sediment and the contaminants contains in the sediment. Good place for indicators.
- Emergent environmental contaminants. Environmental contaminants from developed areas can get into the ecosystem because it can pass right though water treatment plants. This can subsequently affect fish populations (acting like hormones). Water testing has gotten sophisticated enough to start detecting these.
- Measure fish population (biomass) over time and that can tell about the health of the system.
- Chlorophyll: can be physical (amount suspended) or biological (amount present).
- Interest in chloride at Lake Meredith.

Table 4. Aquatic and Landscape Workshop Issue Ranking Results

Total Number of Issues Ranked:	**47**	
Issues Ranked "High"		**14**
Issues Ranked "Medium"	**29**	
Issues Ranked "Low" or "Not an Issue"	**4**	

High

Issues were ranked as "High" priority if al groups that reviewed that issue ranked it as high.

Weather patterns	Exotic plants
Erosion – Slopes, lakeshores	Aquatic exotic plants
Groundwater levels	Woody invasive species
Water quality	Viewshed
Riverine community	Landscape dynamics
Lacustrine community	Fire and fuel dynamics
Riparian community	Native biotic populations/communities

Medium

Issues were ranked as "Medium" priority under the following circumstances: Both groups ranked it as "Medium"; the issue was ranked "high" by one group and "Medium" by the other group; or the issue was ranked as "medium" by one group and "Low" by the other group. Issues noted by an * indicate that one group marked it as high, while another ranked it as medium. Those noted with ^ indicate one group ranked it as a high and one ranked it as a low. Those noted with a # indicate one group ranked it as medium and one ranked it as low.

Wet and dry deposition	Zebra mussels^
Visibility and particulate matter	Mineral, oil, and gas#
Water quantity*	Game birds
E. Coli levels*	Fishing
Arkansas river shiner*	Pollution from non-park sources
Upland springs*	Park visitor effects on natural resources
Wetlands in upland systems	Off-road vehicle use
Cottonwood community*	Soundscape
Arkansas darter#	Night sky
Contaminants in fishery	Invasive native fauna
Migratory songbird stopover area	Soil health
Bald eagle	Flooding processes
Mississippi kites	Nutria
Insect diseases	Bottomland hardwood community
Wildlife disease effects	

Low/Not an Issue

Issues were ranked as “Low” priority only if all groups ranking the issue ranked it as low.

Ozone	Southwestern willow flycatcher
Marsh rice rat	Boundary survey/fencing

Table 5. Final List of Aquatic and Landscape Issues. These issues are being considered as potential vital signs for these systems. They are shown here according to their proposed classifications within the National Vital Signs classification system and their subgroup priority ranking.

Level 1	Level 2	Level 3	Issue Name	Landscape	Rivers + Streams	Reservoirs
Air and Climate	Air Quality	Ozone	Ozone	Low		
		Wet and Dry deposition	Wet and dry deposition	Medium		
		Visibility and Particulate <atter	Visibility and particulate matter	Medium		
	Weather and Climate	Weather and Climate	Weather patterns	High		
Geology and Soils	Geomorphology	Stream/River Channel Characteristics	Erosion – slopes, lakeshores, banks		High	High
	Soil Quality	Soil Function and Dynamics	Soil health		Medium	
Water	Hydrology	Groundwater Dynamics	Groundwater levels		High	High
		Surface Water Dynamics	Water quantity		High	Medium
			Flooding processes along river/stream/lake		Medium	Medium
	Water Quality	Water Chemistry	Water quality		High	High
		Toxics	E. Coli		Medium	Medium
			Contaminants in fishery		Medium	Medium
Biological Integrity	At-risk Biota	T&E Species and communities	Bald Eagle		Medium	Medium
			Arkansas River Shiner		High	Medium
			Arkansas darter		Medium	Low
			Southwestern willow flycatcher		Low	Low
			Marsh rice rat			Low
	Focal Species or Communities	Wetland Communities	Upland springs		High	Medium
			Wetlands in upland systems		Medium	
		Riparian Communities	Cottonwood riparian community		High	Medium
			Riparian community		High	
			Bottomland hardwood community		Medium	Medium
			Riverine community		High	
		Freshwater	Lacustrine community		High	

		Communities				
Level 1	Level 2	Level 3	Issue Name	Landscape	Rivers + Streams	Reservoirs
		Birds	Migratory stopover area		Medium	Medium
			Mississippi kites		Medium	Medium
		Native Biotic Species and Communities	Native biotic species and communities	High		
	Invasive Species	Invasive/Exotic plants	Woody invasive species	High		
			Exotic plants	High	High	High
			Aquatic exotic plants		High	
		Invasive/Exotic animals	Zebra mussels		High	Low
			Nutria		Medium	Medium
			Invasive native aquatic fauna		Medium	
	Infestations and disease	Insect pests	Insect diseases on ecosystem	Medium		
		Animal diseases	Wildlife disease effects on staff and visitors	Medium		
Human Use	Consumptive Use	Consumptive Use	Mineral, oil, and gas extraction	Medium	Medium	Low
			Game birds		Medium	Medium
			Fishing		Medium	Medium
	Non-point Source Human Effects	Non-point Source Human Effects	Pollution from non-park sources	Not an issue	Medium	Medium
	Visitor and Recreation Use	Visitor usage	Effects of park visitors on natural resources		Medium	Medium
			Off-road vehicle use		Medium	Medium
Landscapes	Viewscape	Viewscape/Night Sky	Viewshed	High		
			Night sky	Medium		
	Fire	Fire and Fuel Dynamics	Fire and fuel dynamics	High		
	Landscape Dynamics	Landscape Dynamics	Boundary survey/fencing	Not an issue		
			Landscape dynamics (land cover, condition, connectivity, pattern)	High		
	Soundscape	Soundscape	Soundscape	Medium		

Appendix 1. Draft landscape conceptual models developed by Todd Swannack and aquatic models by Sue Braumiller that were presented at the workshop.

Figure A1. Jenny Chapin Model. Bold-type font indicates state factors, and italic-type font are the interactive controls. The circle represents the boundary of the ecosystem.

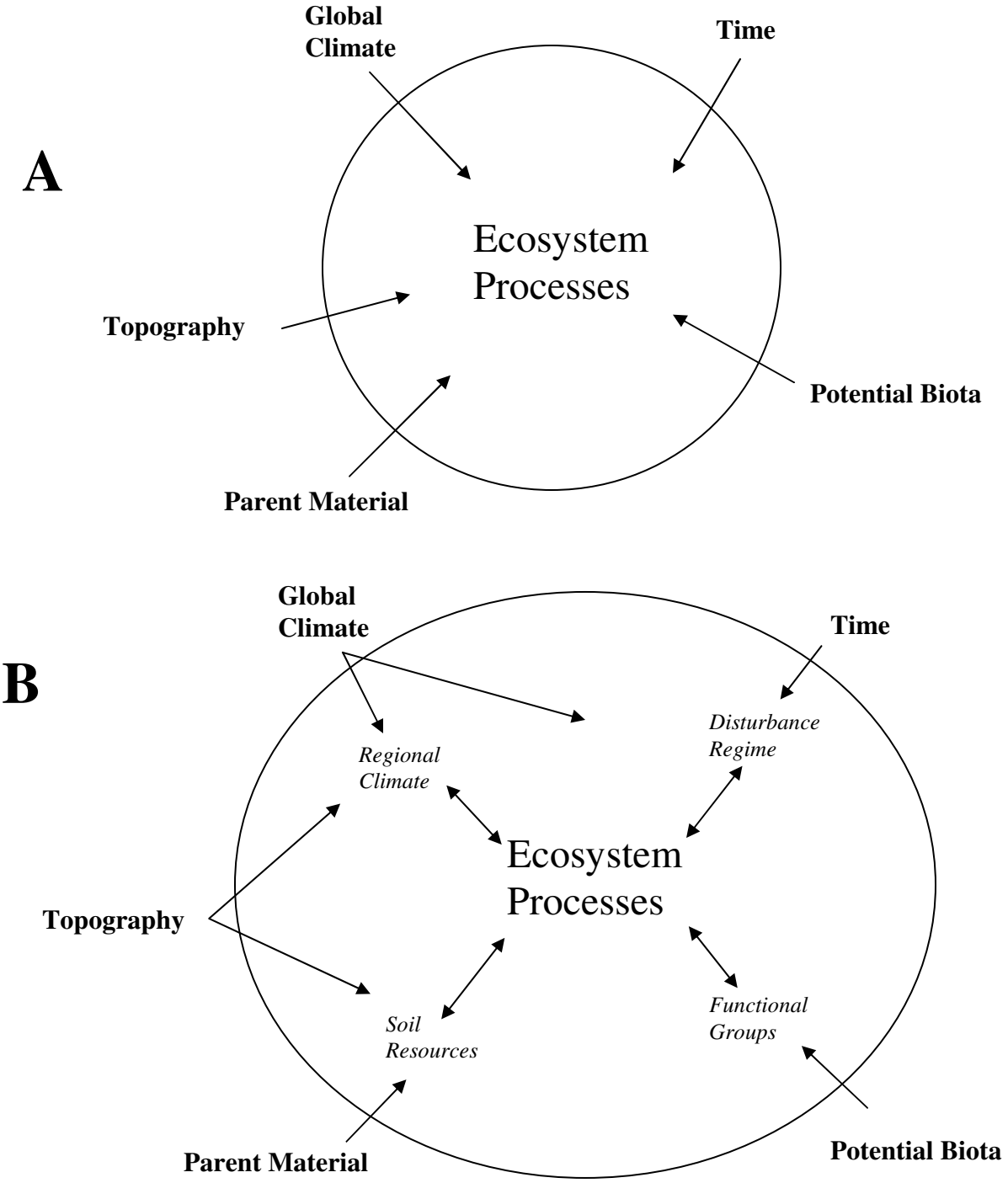

Figure A2. – Current processes creating landscape pattern. Circles represent processes responsible for creating landscape pattern. The square represents the landscape of interest (the park and surrounding lands). Arrows represent the direction of influence. The dotted line represents the indirect influence from human-mediated activities on natural processes (e.g., global climate change induced by growing human population)

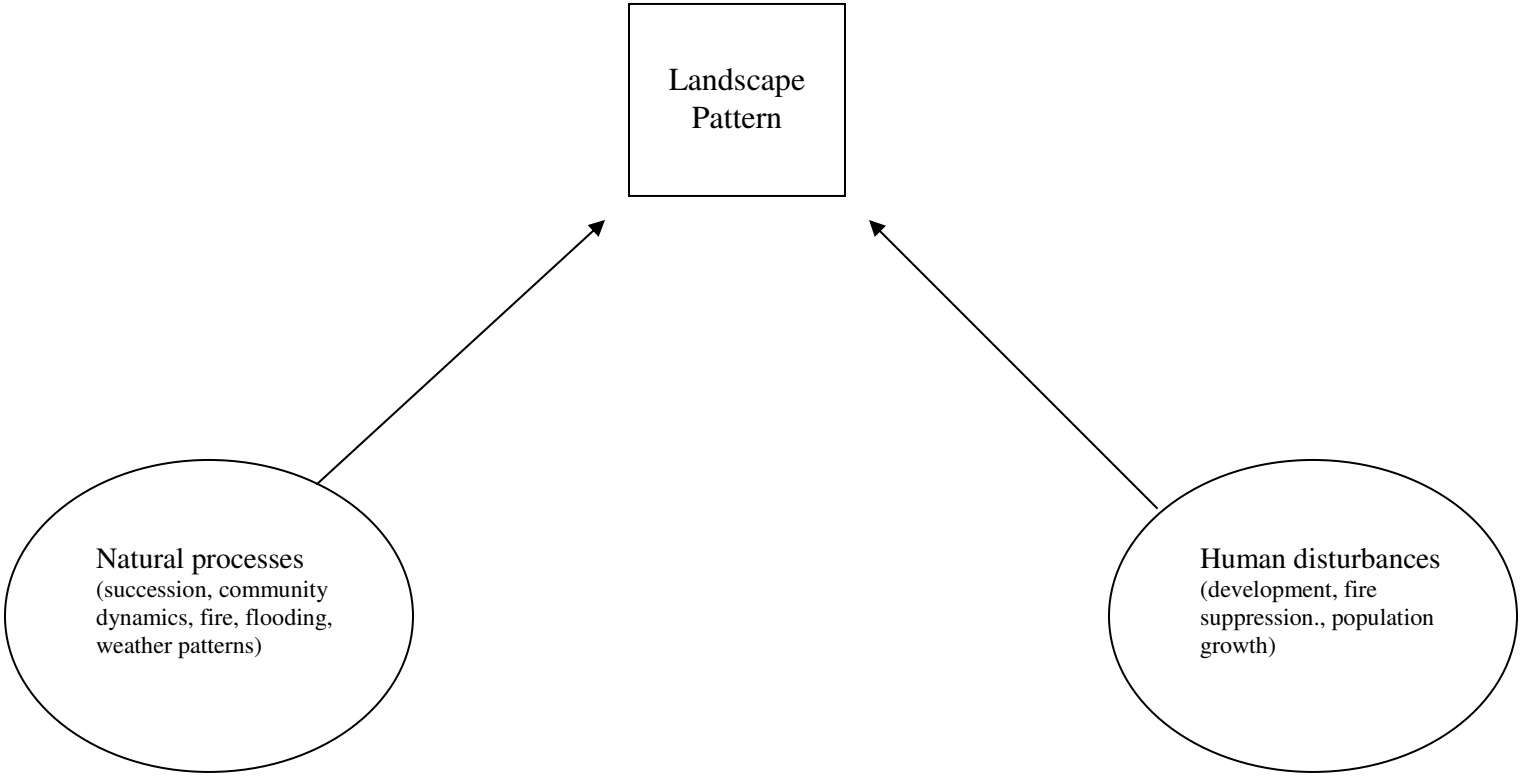

Figure A3. – Types of development and resulting effects on the landscape pattern of the SOPN. Squares represent development types (stressors). Circles are variables representing ecological effects of development. Bold-type font indicates the major ecological processes affected by development and each of those variables has its own submodel. Small arrows point to the major types of disturbance each development type causes, and the large solid arrow represents direction of influence.

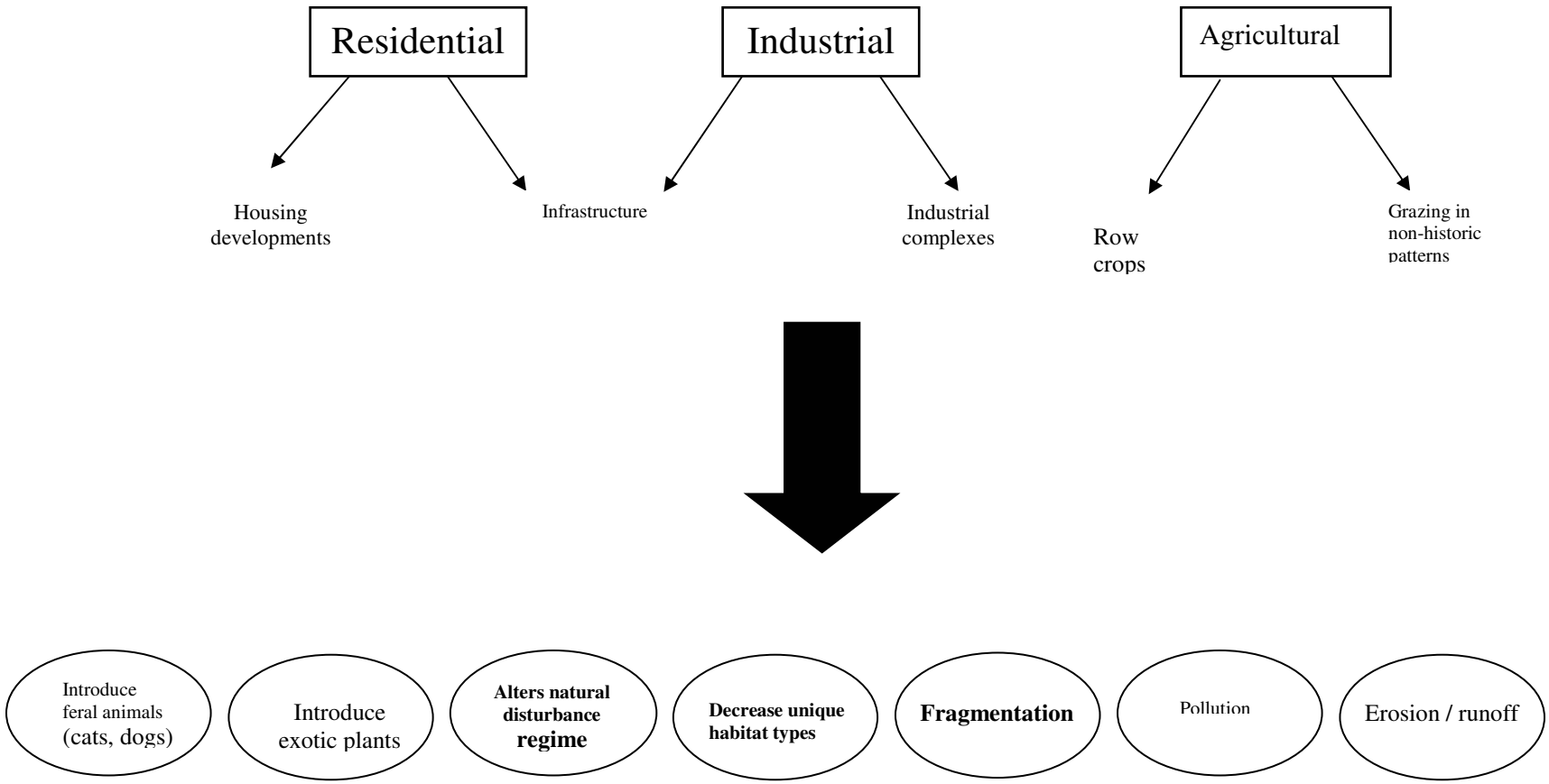

Figure A4. – Diagrammatic representation of a natural disturbance regime. The arrows represent the direction of influence.

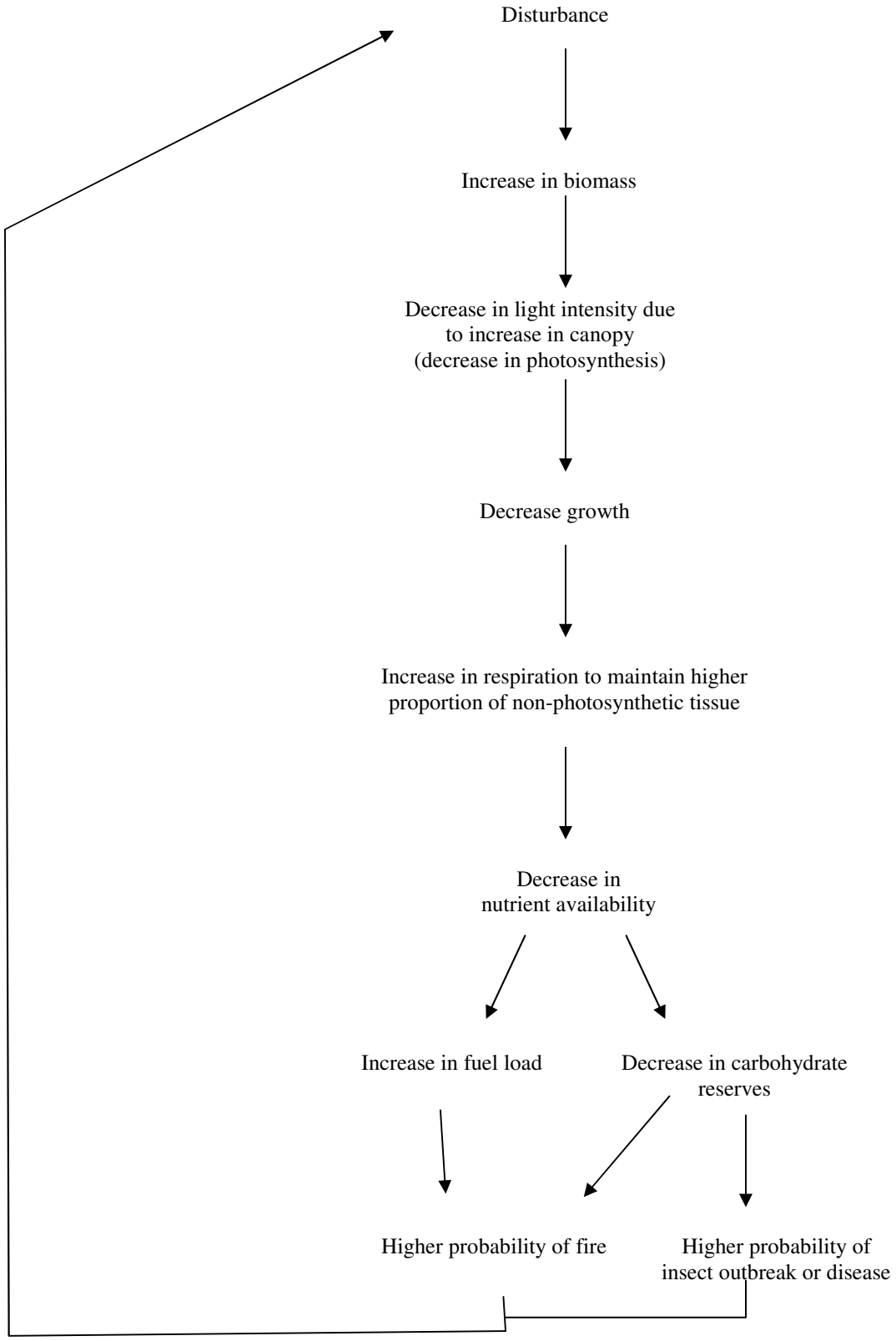

Figure A5. – Submodel representing the effects of altering the natural disturbance regime within an ecosystem. The arrows point to the factors resulting from an altered disturbance regime.

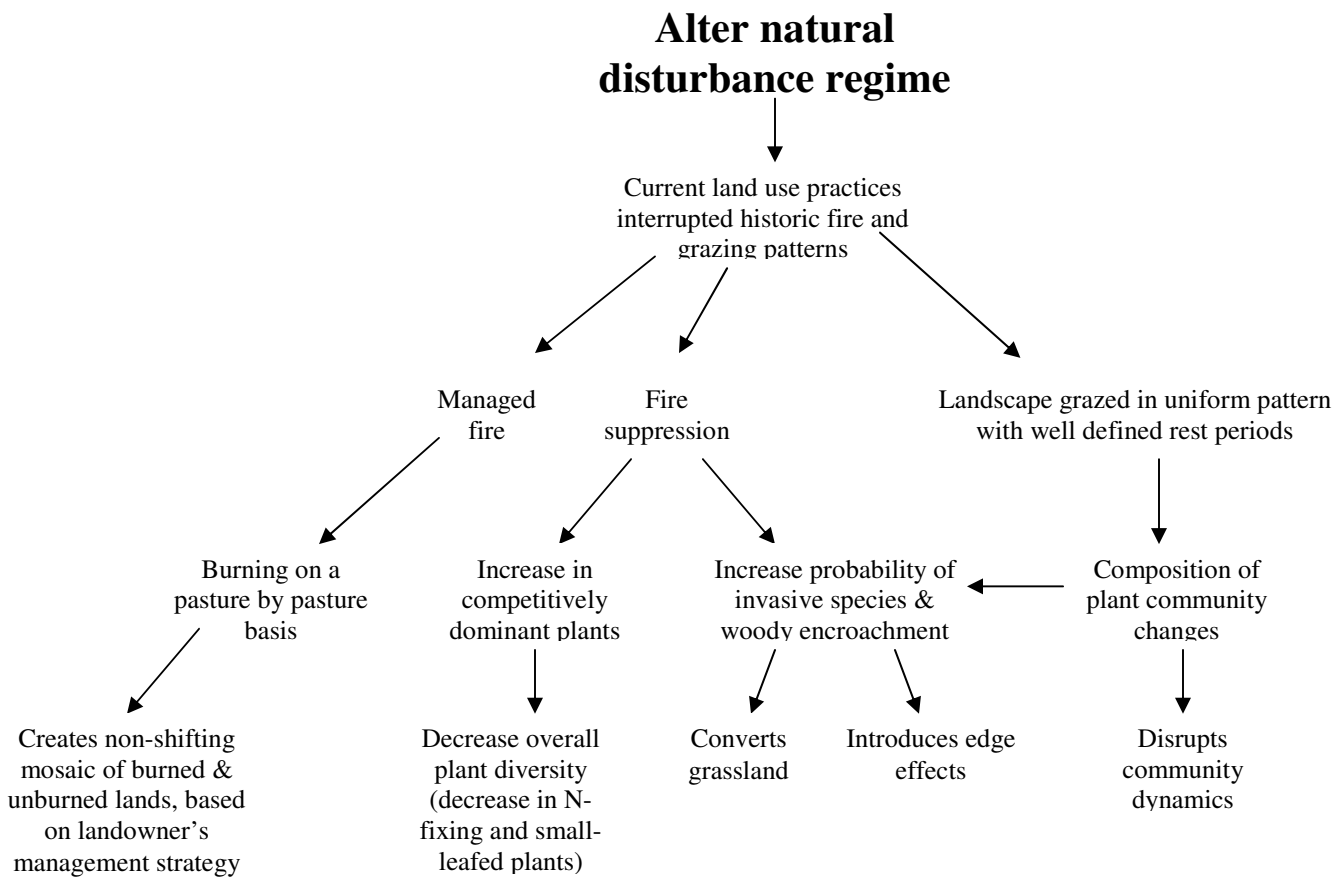

Figure A6. – Submodel representing the effects of decreasing or decimating rare and unique habitats. The arrows point to the factors resulting from a decrease in rare and unique habitat types.

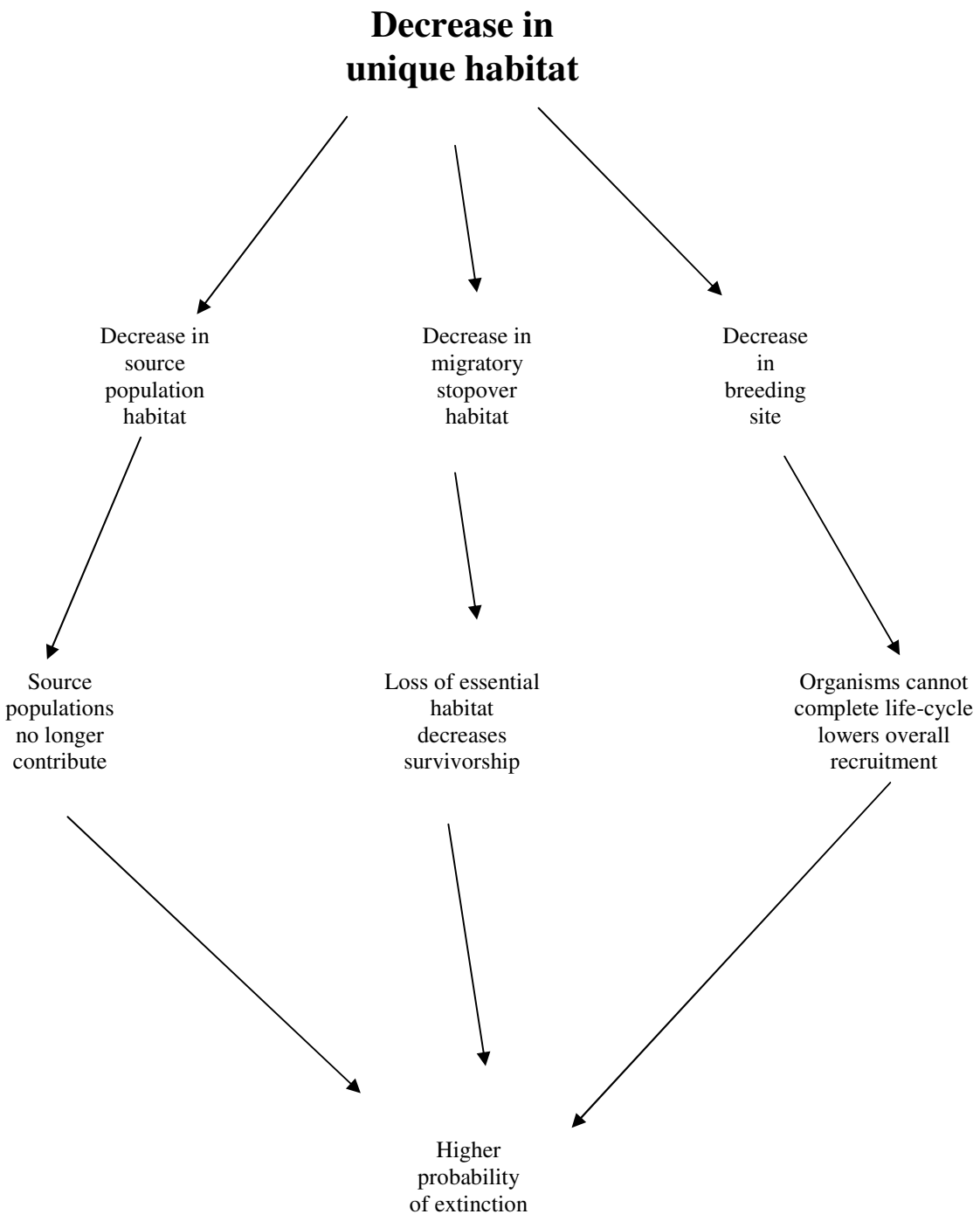

Figure A7. – Submodel diagramming the major effects of ecosystem fragmentation. The arrows point to the factors resulting from fragmentation. The dotted lines represent feedback into the variable.

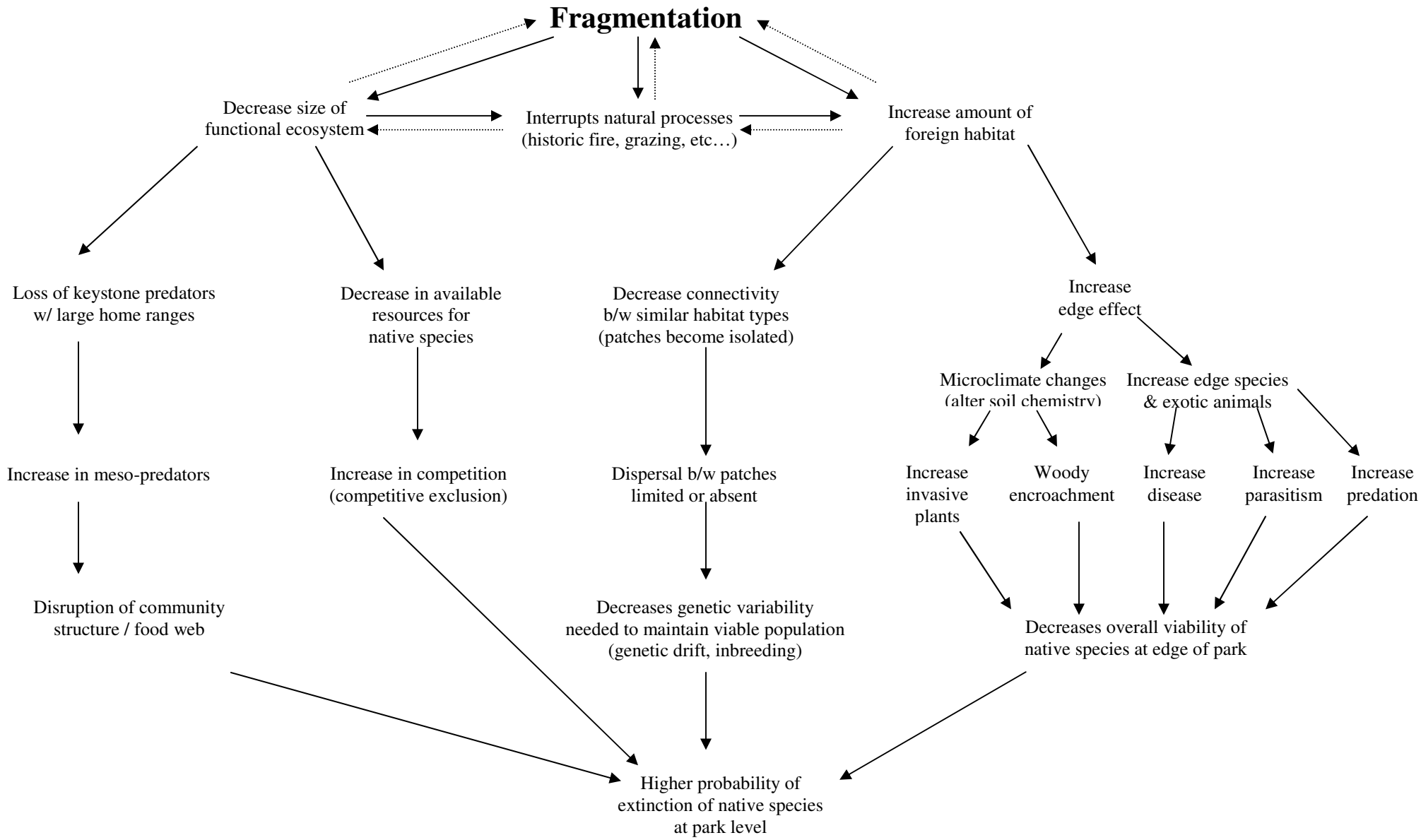

Figure A8. Overarching stream model.

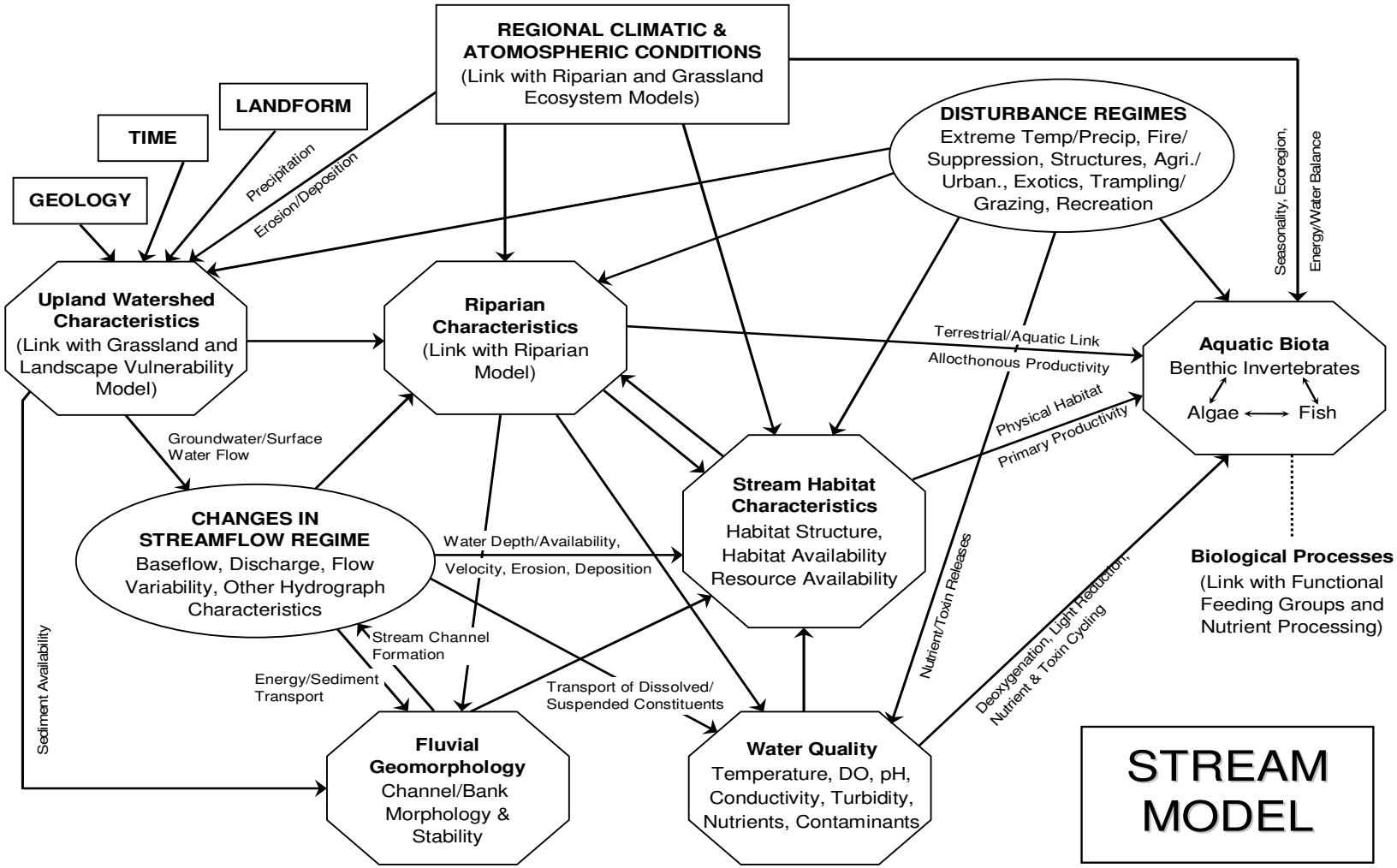

Figure A9. Stream drought submodel.

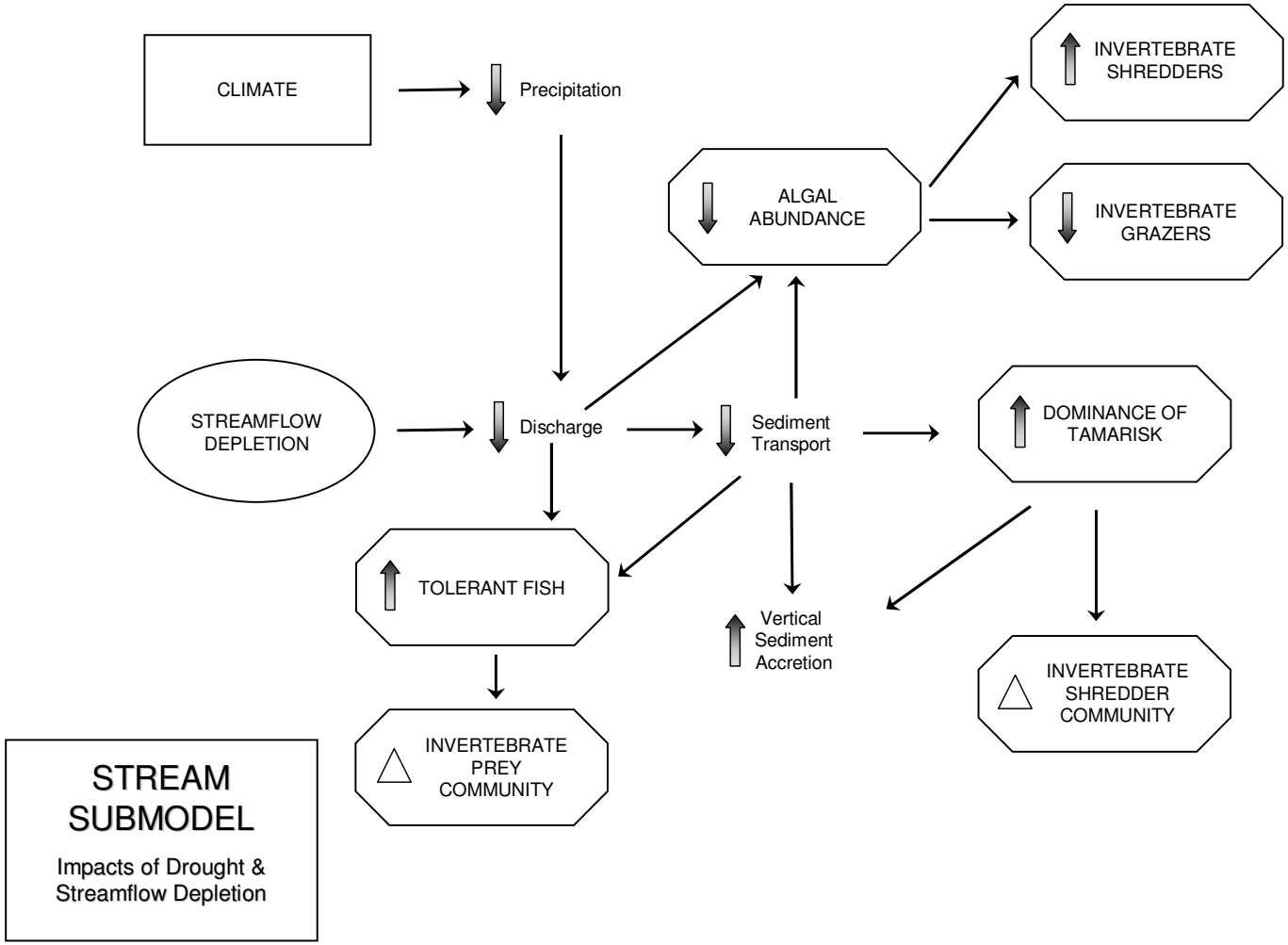

Figure A10. Stream roads submodel.

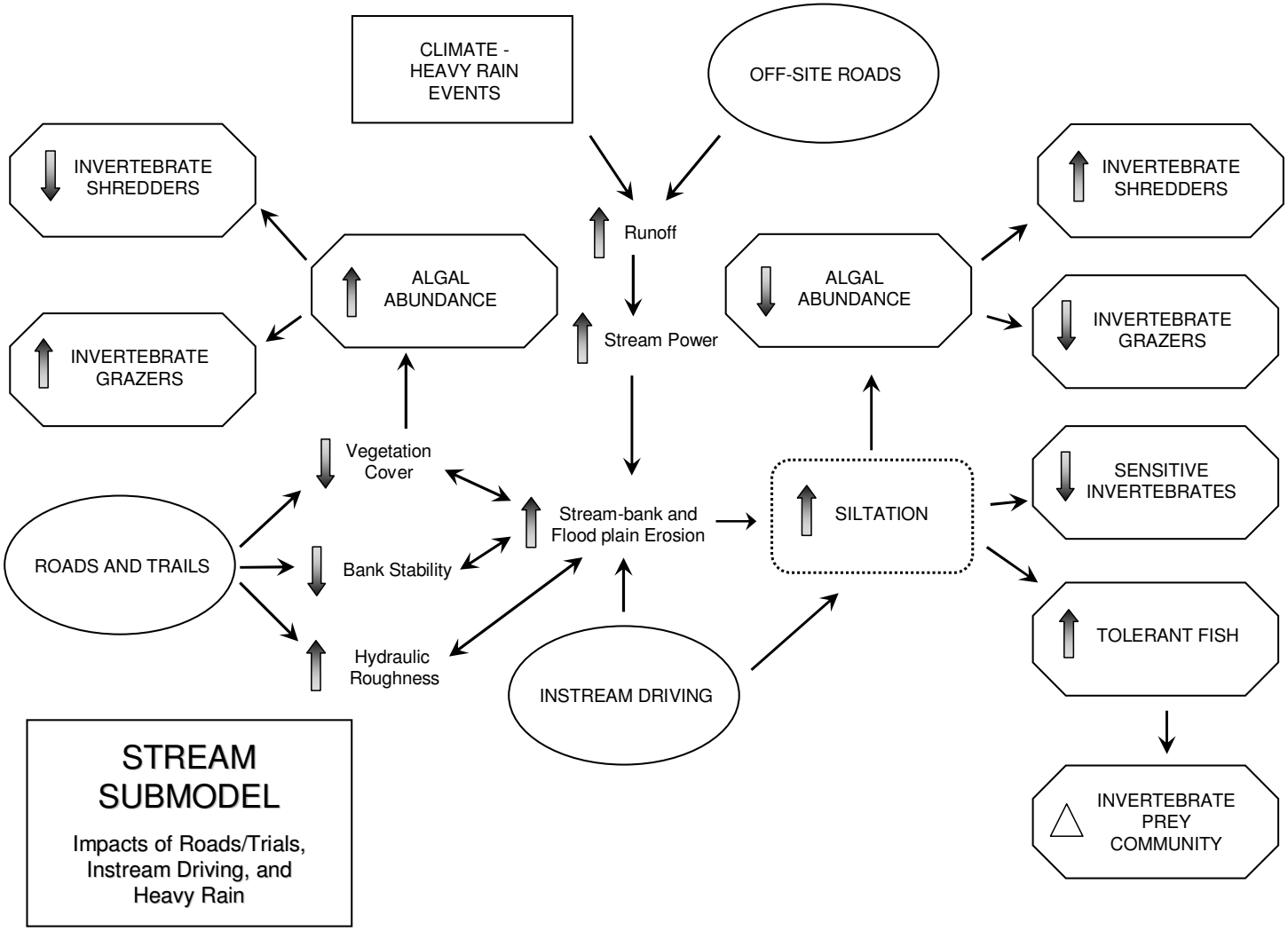

Figure A11. Stream grazing submodel.

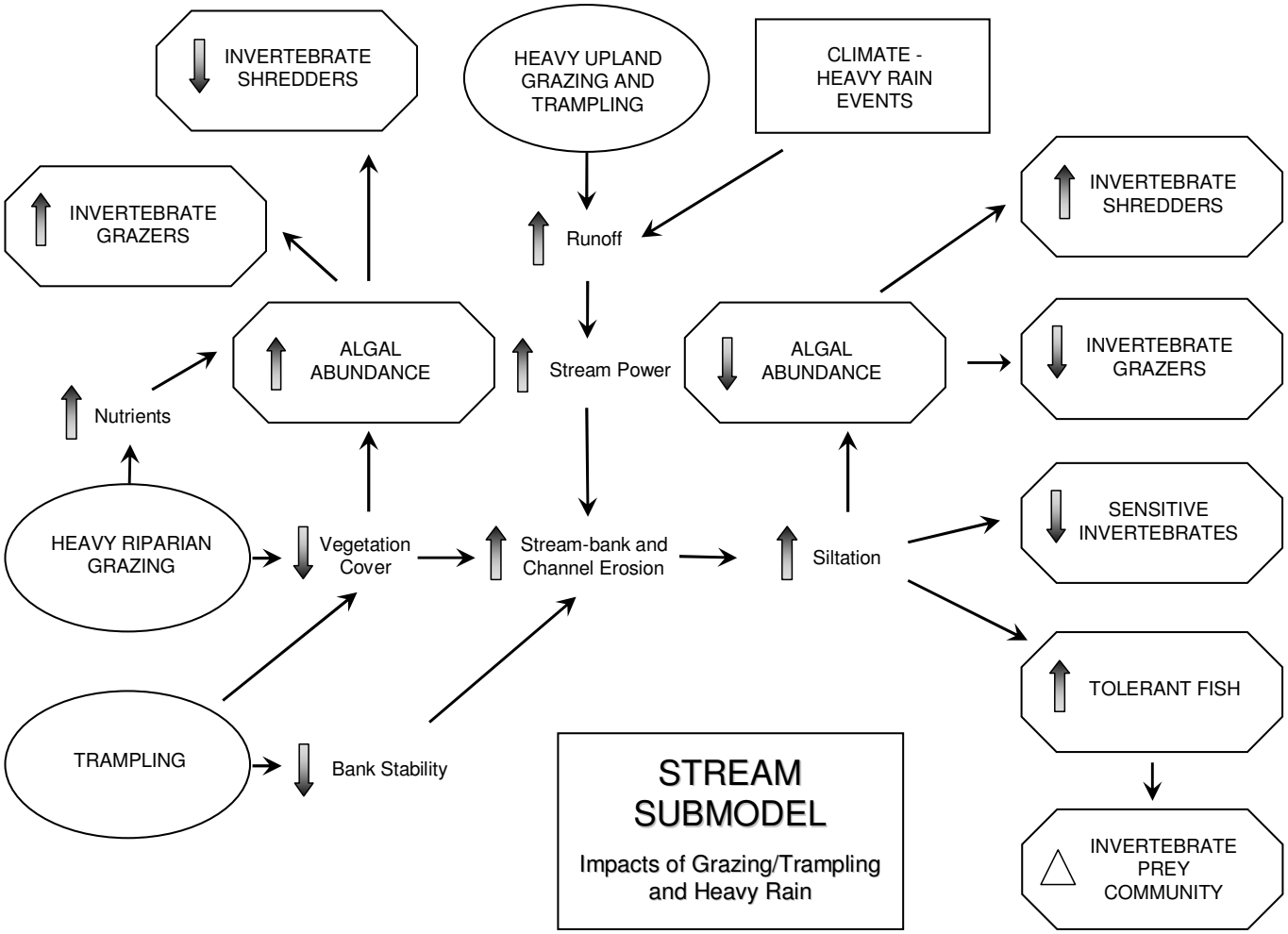

Figure A12. Stream fire and logging submodel.

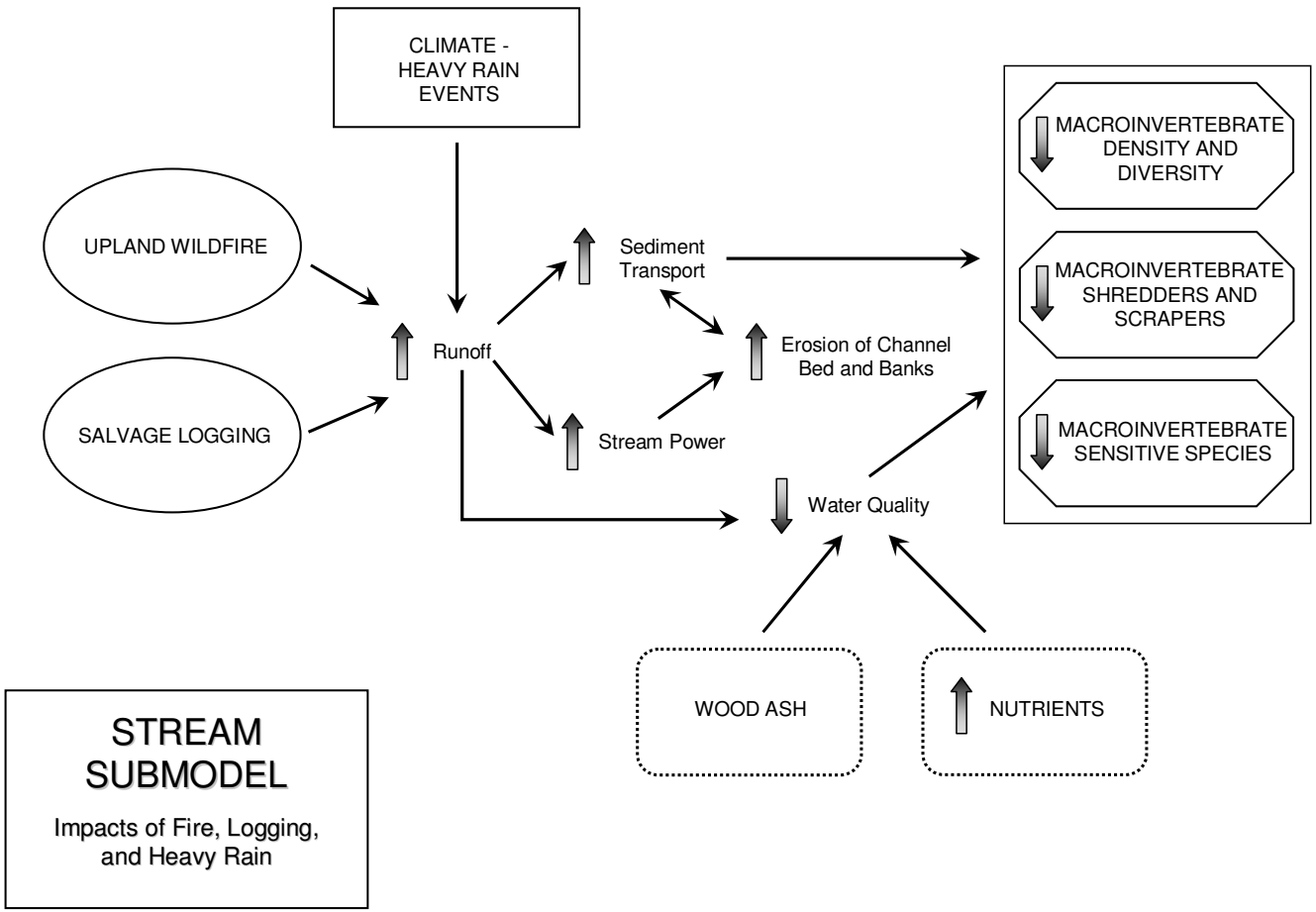

Figure A13. Reservoir overarching model.

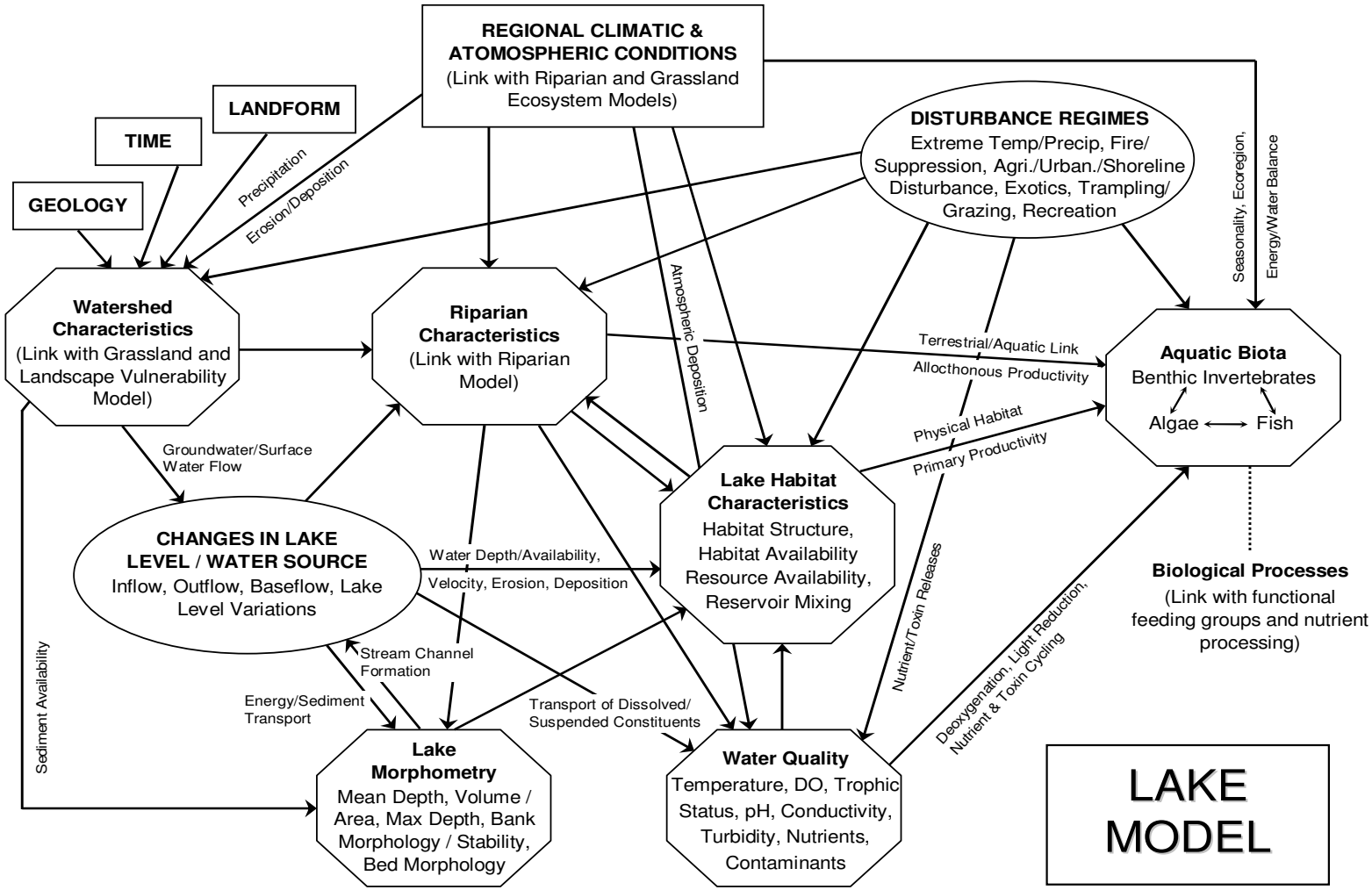
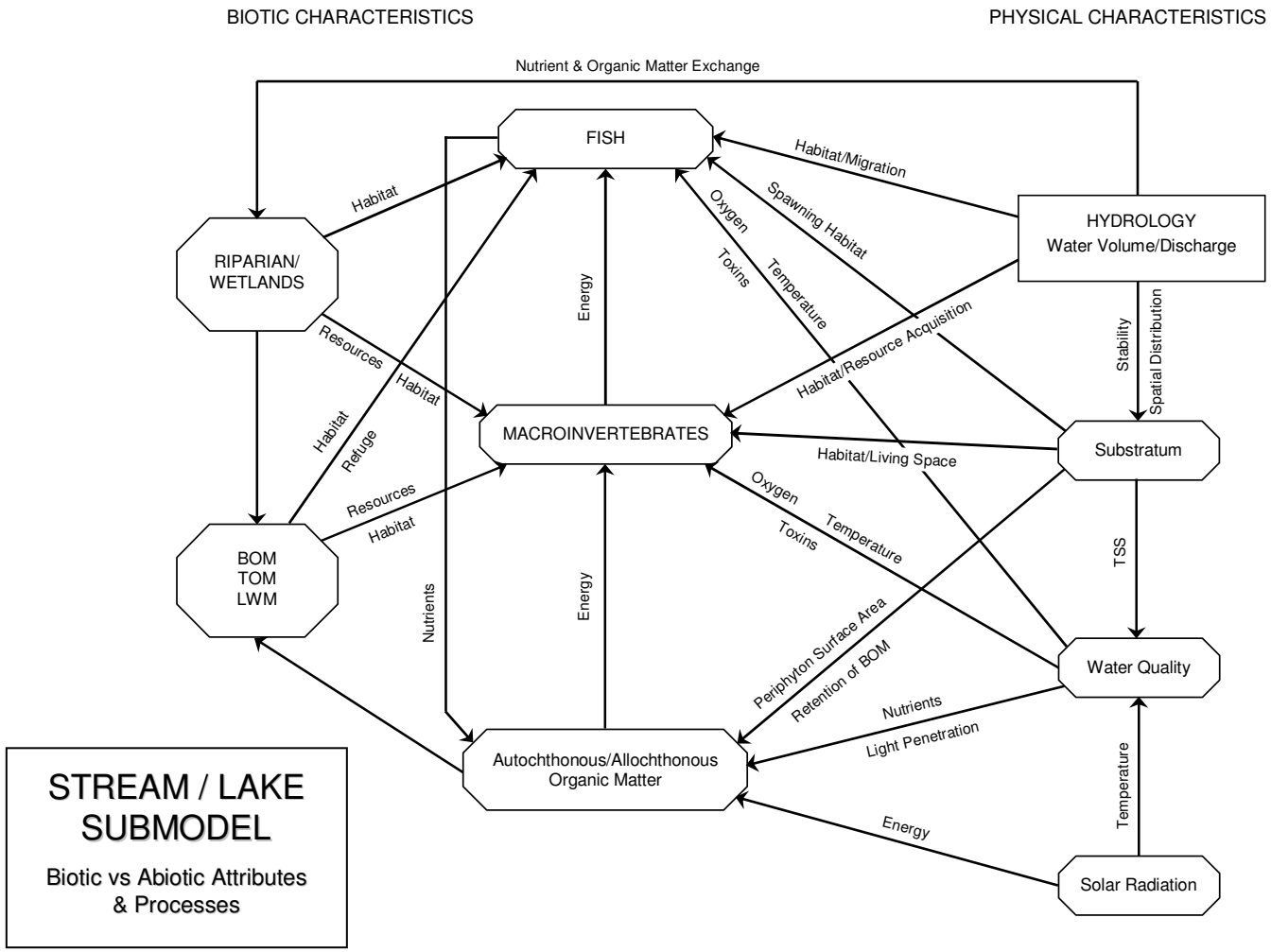
Figure A14. Biotic versus abiotic attributes submodel.