Developing and calibrating an indicator for biogeochemical condition of headwater riparian ecosystems

R. Rheinhardt[1,2], M. Brinson[1], R. Christian[1], K. Miller[1,3], G. Meyer[1]

[1] Dept. of Biology, East Carolina University, Greenville, NC 02858
[2] 415 County Road, Pocasset, MA 02599
[3] North Carolina Ecosystem Enhancement Program, Raleigh, NC 27699
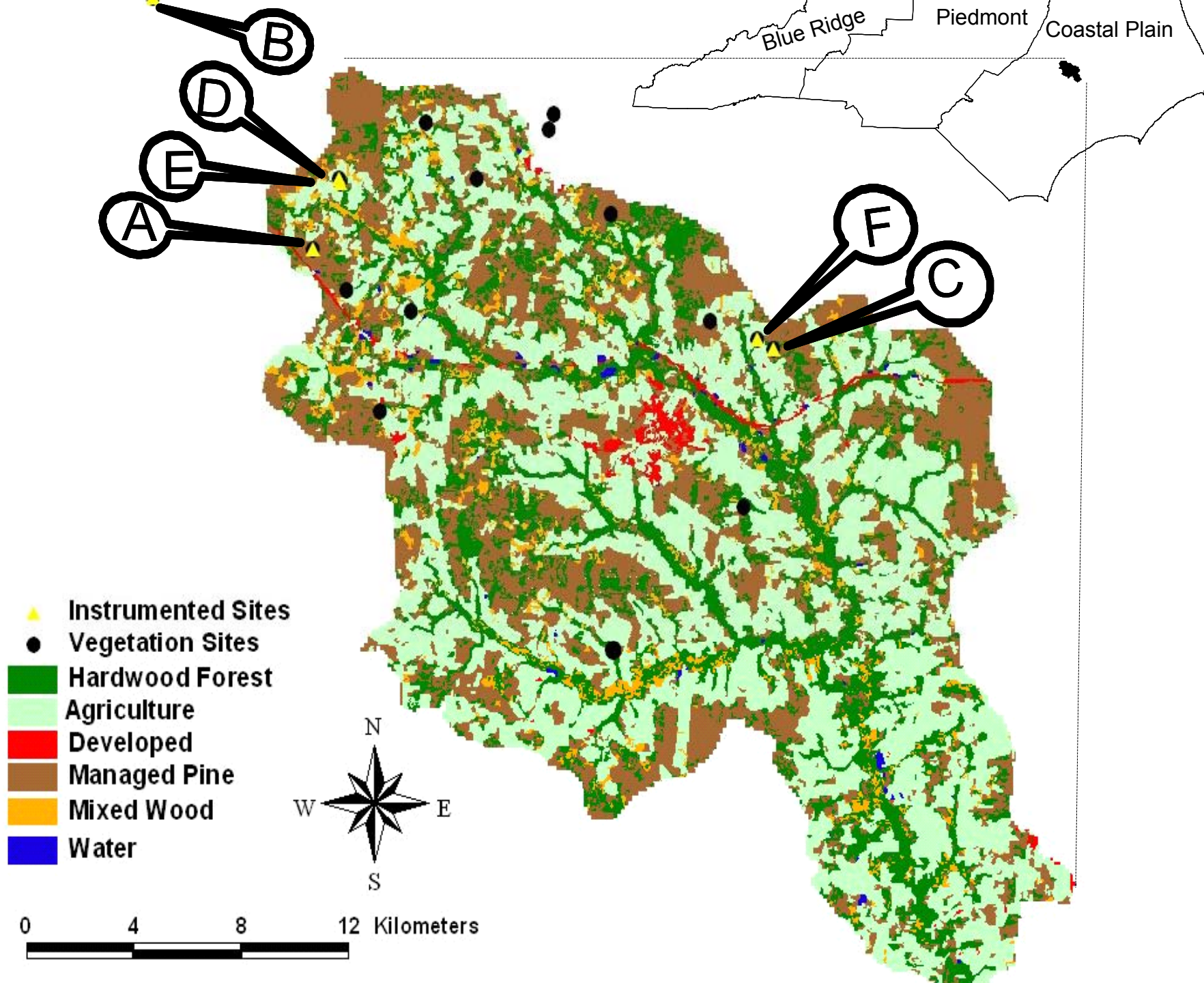
Objectives

1. Summarize development of 2 indicators of condition for riparian headwater ecosystems

2. Provide overview of how the indicators were calibration based on field data

3. Show how indicators are applied to the assessment of aquatic condition of headwater riparian ecosystems in NC

Criteria for identifying indicators in headwater ecosystems

1. Based on reference conditions in coastal plain agricultural landscapes
2. Can be rapidly assessed in the field
3. Provide for condition evaluation relative to ecosystem functioning

Blue Ridge Piedmont Coastal Plain

Legend:

▲ Instrumented Sites
● Vegetation Sites
■ Hardwood Forest
■ Agriculture
■ Developed
■ Managed Pine
■ Mixed Wood
■ Water

N
W — E
S

0 4 8 12 Kilometers

Landscape of Inner Coast Plain, NC: stream order by total length and area

Order	% Total length	Cumulative % length	Drainage Basin (ha)
0	?	?	?
1	62	62	287
2	18	80	796
3	6	86	2,524
4	6	92	10,790
5	2	94	44,354
6+	6	100	?

Major factors contributing to riparian aquatic condition

1. Condition of stream channel
2. Condition of near-channel riparian zone (buffer zone)
3. Condition of contributing drainage basin
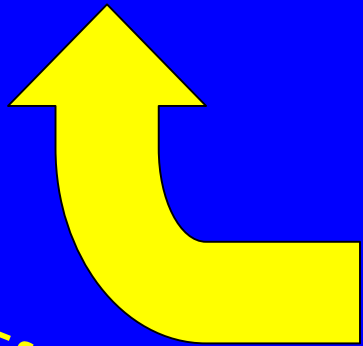
CONTRIBUTORS TO CONDITION

1. Stream channel
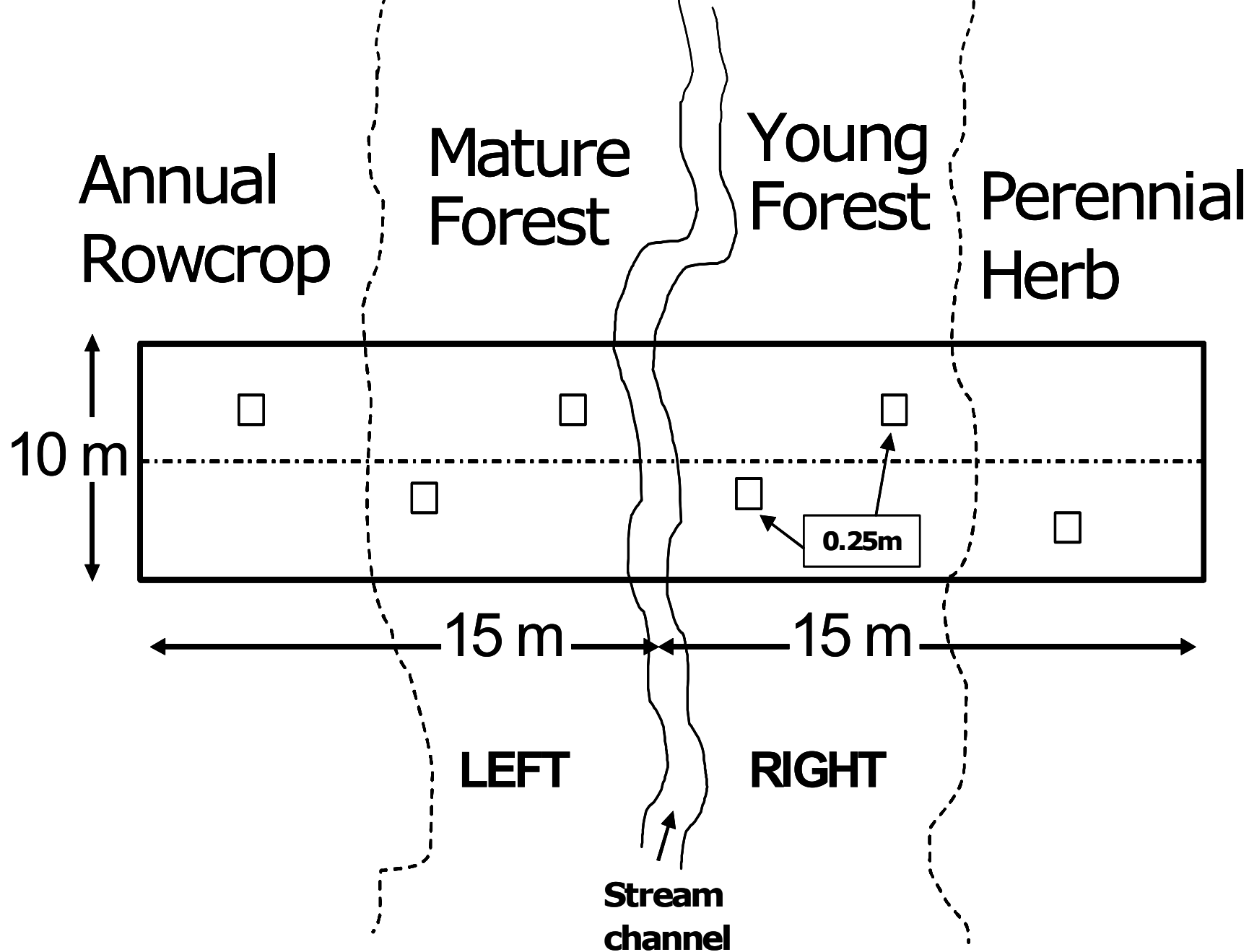2. Riparian buffer
3. Contributing watershed

Effect on functions

Effect on channel/riparian condition
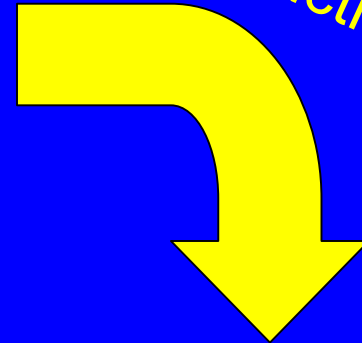
FUNCTIONS (0.0-1.0)	STREAM	RIPARIAN ZONE
Hydrologic		
Biogeo-chemical (WQ)		
Habitat		

METHODS: Living Biomass Component

| CATEGORY	DEFINITION	SOURCE
Trees	Canopy species ≥ 2.5 cm dbh	Literature values, dry wt.
Shrubs	Non-canopy species < 2.5 cm dbh, ≥ 1-m tall	Dry wt. regression eqns. based on group dimensions
Saplings	Canopy species < 2.5 cm dbh, ≥ 1-m tall	Dry wt. based on mean of group
Herbs	Non-woody vegetation	¼ m² plots, dry wt., or lit. values for ag. crops
Vines	Woody vines	¼ m² plots, dry wt.
Seedlings	Woody species < 1-m tall	1/4-m² plots, dry wt.

METHODS: Detrital Biomass Component

CATEGORY	DEFINITION	SOURCE	(Mg/ha)
Snags	Standing dead trees ≥ 2.5 cm dbh (5 decay classes)	Literature & regression eqn.	Dry wt.
LDW	Large Down Wood > 5 cm dia., 5 decay classes)	Regression eqns.	Dry wt.
Soil OM	Organic matter in top 10 cm of soil	Core from 1/4-m^2 plots	Loss on ignition
Litter	Leaves, dead vegetation, and wood < 5-cm dia	1/4-m^2 plots above mineral soil	Dry wt.

Cover types in reference reaches for which biomass was determined
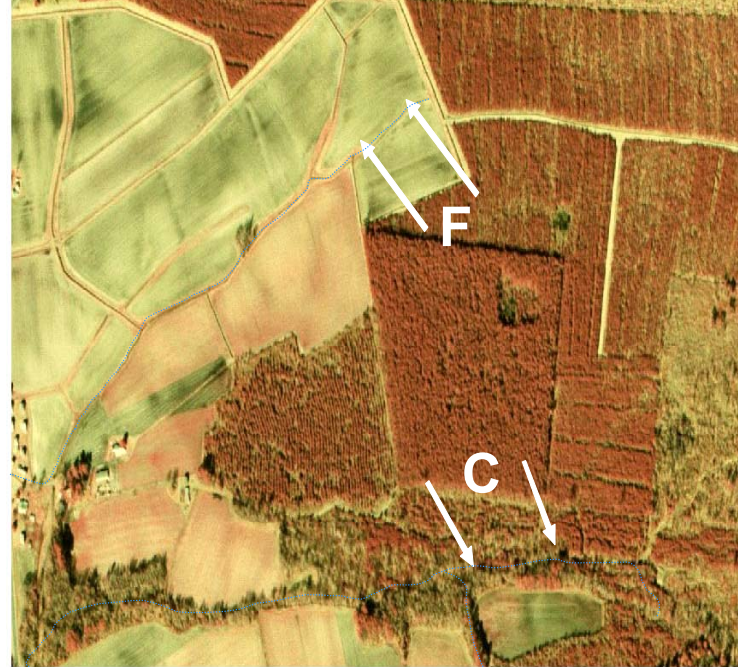
1. Mature forest (> 50 years old)
2. Young forest (25-50 years old)
3. Successional forest (5-25 years old)
4. Recently clear-cut (0-5 years old)
5. Shrub/saplings
6. Perennial herb (fallow fields, lawns, pasture)
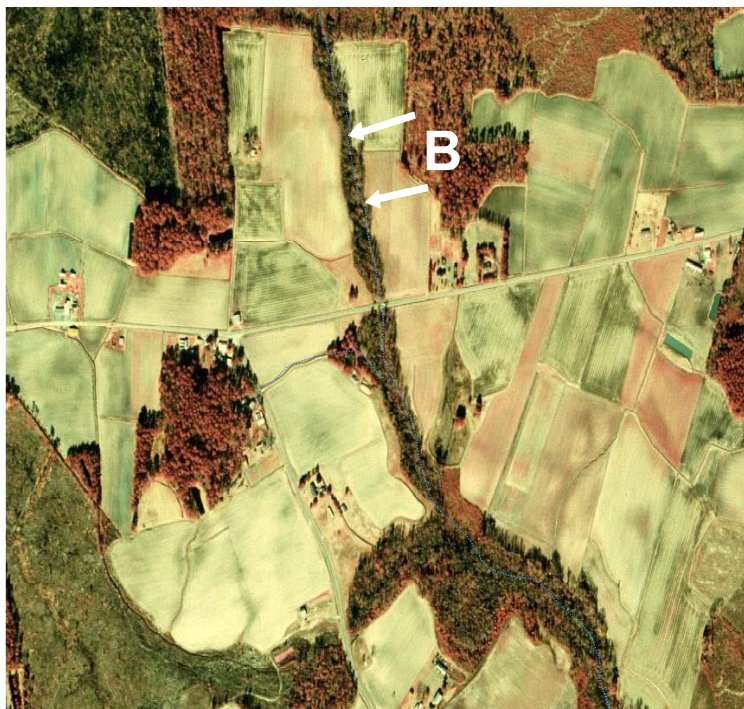7. Annual rowcrop agriculture
8. Impervious (suburban)
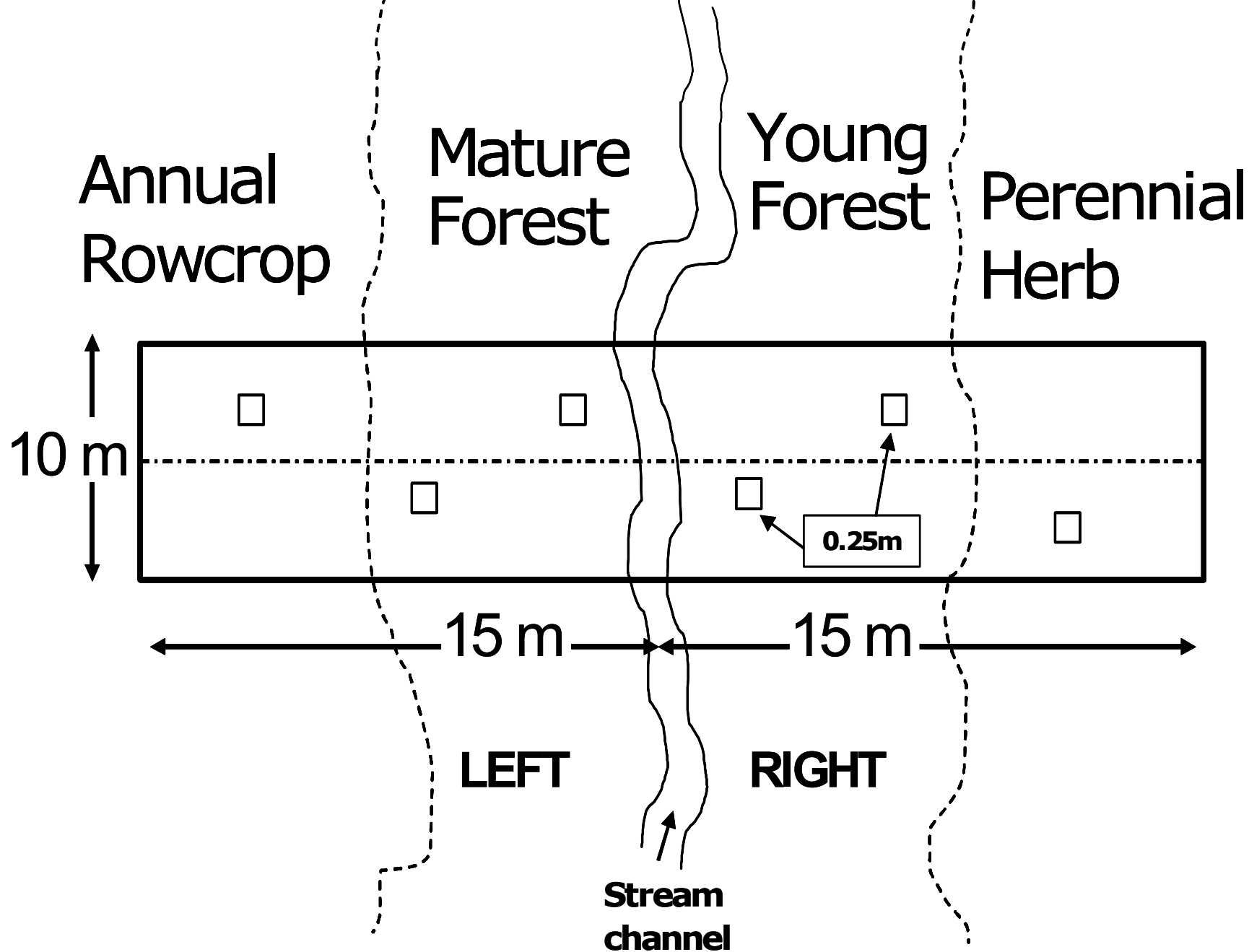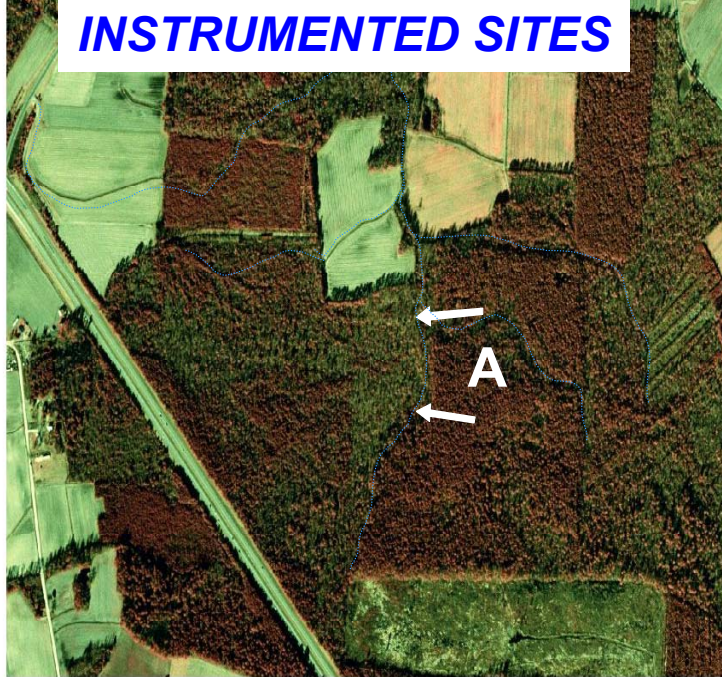
INSTRUMENTED SITES

General condition of instrumented sites
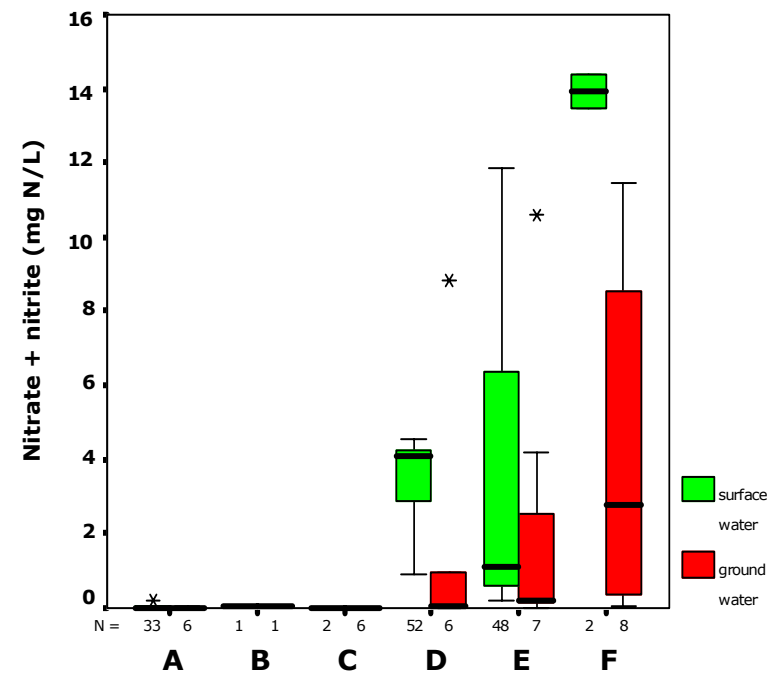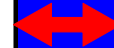
Reach	Channel Condition	Riparian Zones		
		(0-3 m)	(3-15 m)	(15-30 m)
A	Natural	Forest	Forest	Forest
B	Natural	Forest	Forest	Partial rowcrop
C	Natural	Forest	Forest	Partial rowcrop
D	Channelized	Forest	Perennial herb	Rowcrop
E	Channelized	Perennial herb	Perennial herb	Rowcrop
F	Channelized	Perennial herb	Perennial herb	Rowcrop
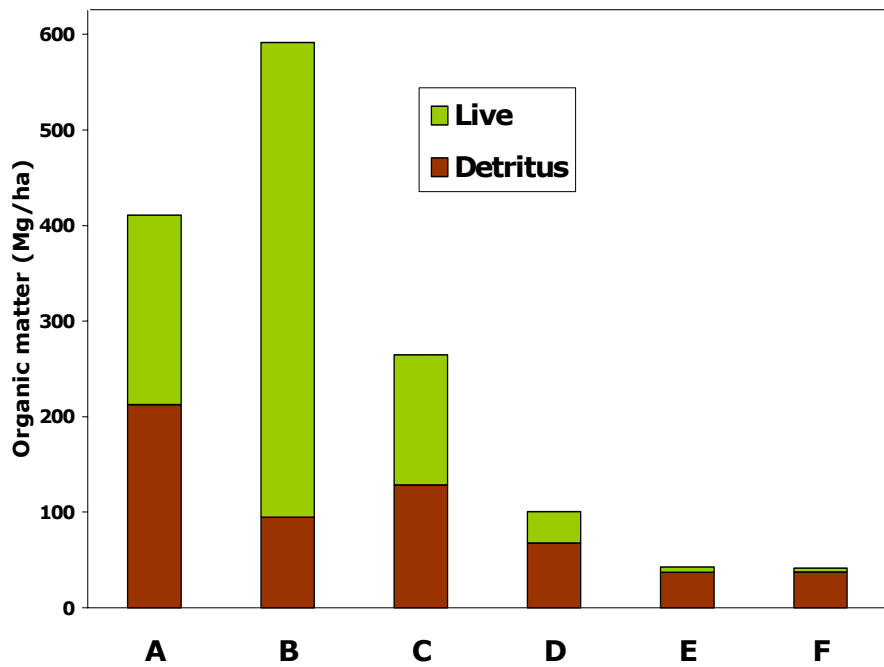
Total biomass of riparian study reaches arranged from least altered (left) to most altered ones (right).

Nitrate plus nitrite concentrations in surface and groundwater sampled under a range of flow regimes and seasons over a 1-year period.

Conclusion: Streams buffered by forest are more effective in sequestering nutrients entering riparian areas from adjacent uplands than are streams with partially forested or herbaceous buffers.
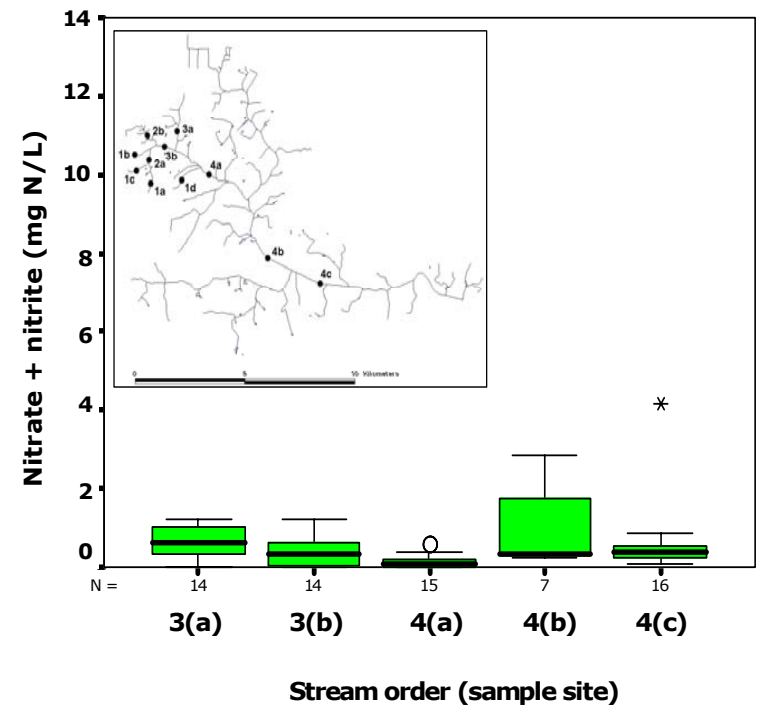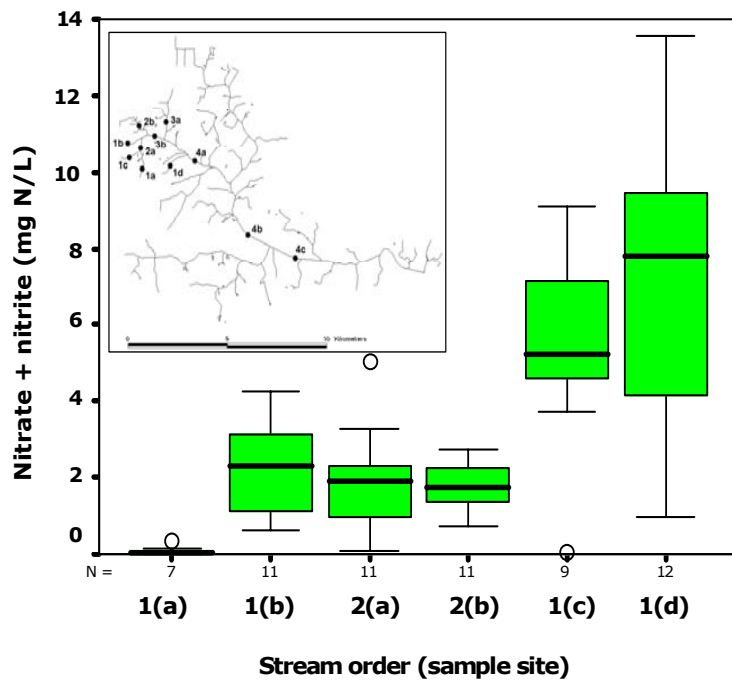
Nitrate plus nitrite concentrations in headwater reaches (1st -2nd order) sampled over a 1-year period under a range of flow regimes.

Nitrate plus nitrite concentrations in 3rd and 4th order streams sampled over a 1-year period under a range of flow regimes.

Conclusion: Nutrient concentrations in higher order streams do not vary with riparian condition, reflecting the flow-weighted aggregation of all streams in the drainage basin more than local riparian condition.
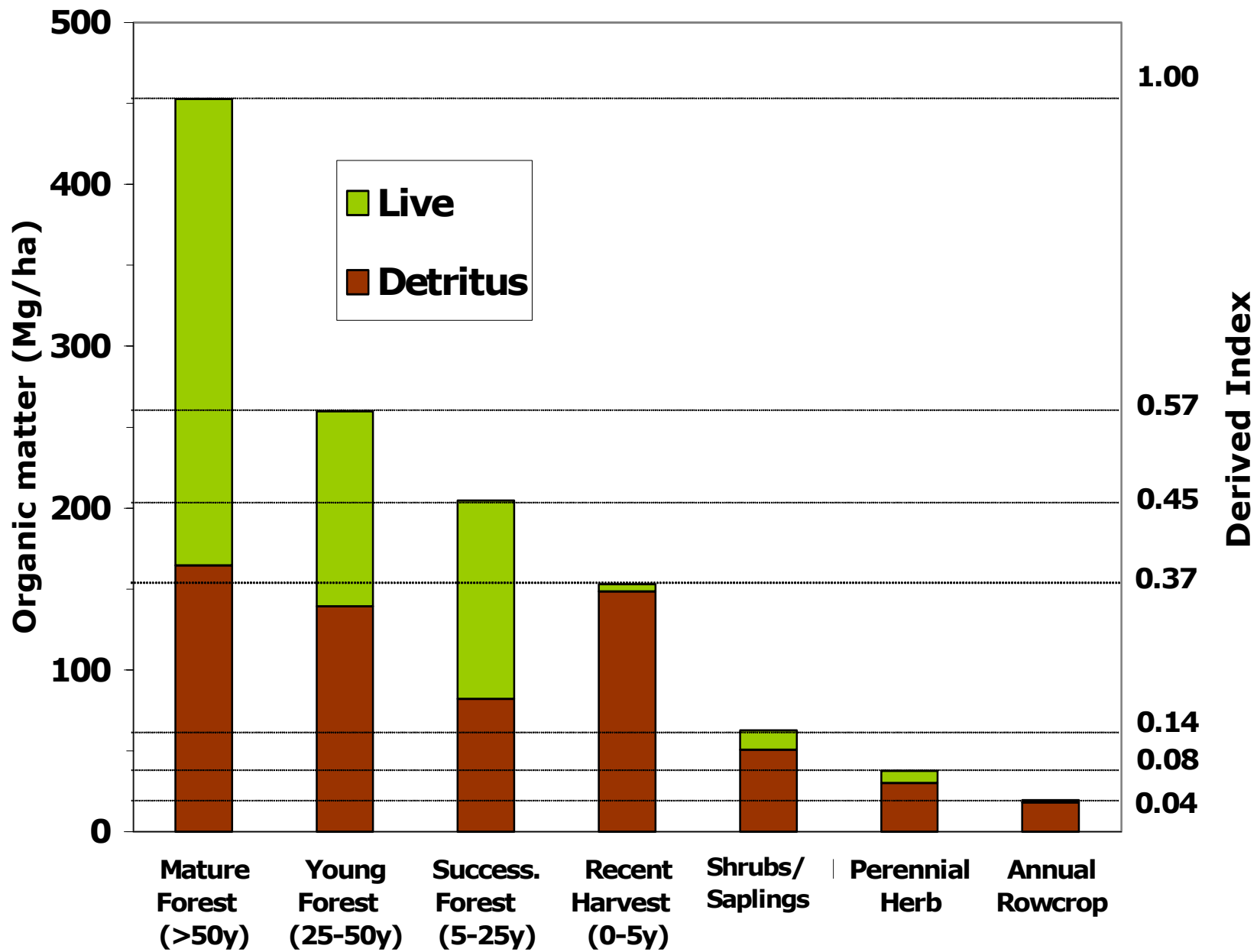
1. Riparian Zone Cover (RZC).

Land use by cover type	kg/ha	Index	RIGHT SIDE ZONE (distance from stream)		
			0-3 m	3-15 m	15-30 m
Mature Forest	453.0	1.00	20	25	5
Young Forest	259.7	0.57	11	14	3
Successional Forest	204.7	0.45	9	11	2
Recently harvested	152.9	0.34	7	8	2
Shrubs/Saplings	62.7	0.14	3	3	1
Perennial Herb (incl. residential lawns)	37.5	0.08	2	2	0
Annual Rowcrop	19.7	0.04	1	1	0
Suburban/impervious	0.0	0.0	0	0	0
Zone Score (column)			11	11	2
				Total score:	24

Near-stream
Cover (NSC)
(0-3 m)

Riparian Zone
Cover (RZC)
(0-30 m)
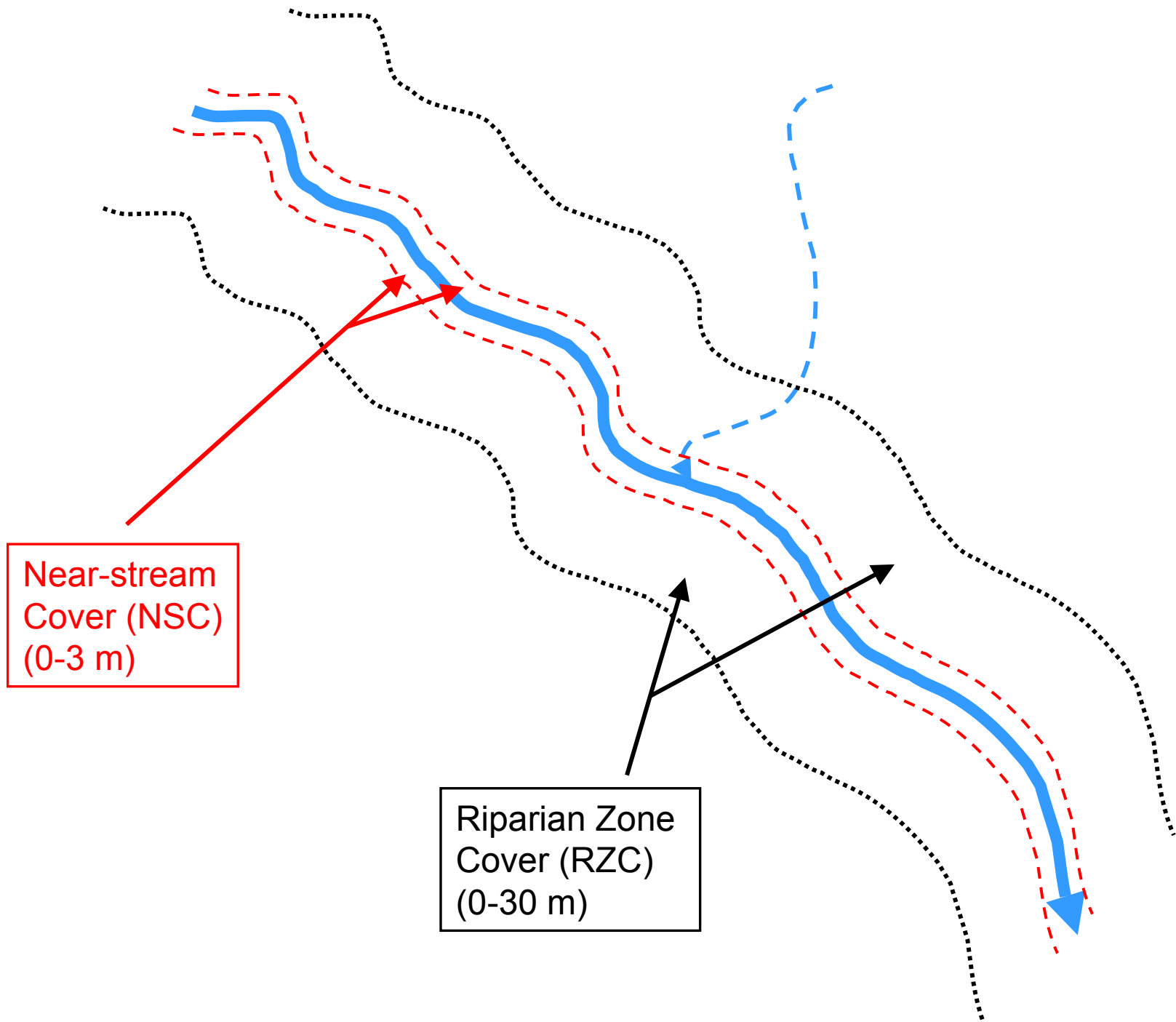
2. Near-stream cover (NSC).

Land use by cover type	RIGHT SIDE ZONE (distance from stream)		
	0-3 m	3-15 m	15-30 m
Mature Forest	20	25	5
Young Forest	11	14	3
Successional Forest	9	11	2
Recently harvested	7	8	2
Shrubs/Saplings	3	3	1
Perennial Herb (incl. residential lawns)	2	2	0
Annual Rowcrop	1	1	0
Suburban/impervious	0	0	0
Zone Score (column)	11	11	2
	Total score:		11

Indicators used to determine functioning of a riparian ecosystem

INDICATORS	HYDROLOGY		BIOGEOCHEMISTRY		HABITAT	
	STREAM CHANNEL	RIPARIAN ZONE	STREAM CHANNEL	RIPARIAN ZONE	STREAM CHANNEL	RIPARIAN ZONE
Riparian zone cover (RZC), p. 3. ⬅	▓		▓		▓	
Near-stream cover (NSC), p. 3. ⬅	▓	▓		▓		▓
Instream woody structure (SRC #1, p. 5)		▓		▓		▓
Sediment regime (SRC #2, p. 5)	▓			▓	▓	
Channel-riparian zone connection (SRC #3 score, p. 5)						
On/off site factors affecting stream channel (SRC #4, p. 6)		▓		▓		▓
On/off site factors affecting riparian zone reach (SRC #5, p. 6)	▓		▓		▓	
Composition and structure of vegetation in riparian zone (SRC #6, p. 6)	▓	▓	▓		▓	
Function Score: For each function and location (stream vs. riparian zone), obtain mean of all appropriate indicator scores.						
FUNCTION INDEX (divide above mean by 100)						

ALL FUNCTIONS