Fish Assemblage Reponses to Water Withdrawals and Water Supply Reservoirs in the Georgia Piedmont

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Issue:

↑ Population growth

↑ Water supply demands

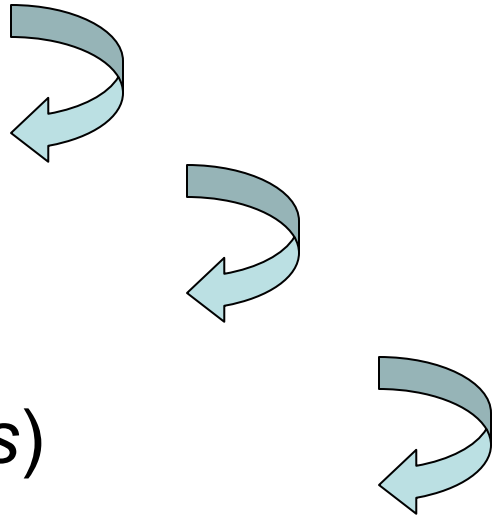
↑ Alteration to stream systems

(*Withdrawals, impoundments*)

↓ Capacity to support aquatic biodiversity

Flow depletion and instream impoundments:

- *habitat alteration*
- *stream fragmentation*



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Management Questions

Tough question!
- flow variability?
- approach?

Instream Flow policy:

How much flow is needed to protect integrity of stream assemblages?

"Ecological safe-yield" approach:

How much can flow regimes be altered without compromising biotic integrity?

- Variability implicit
- Empirical approach

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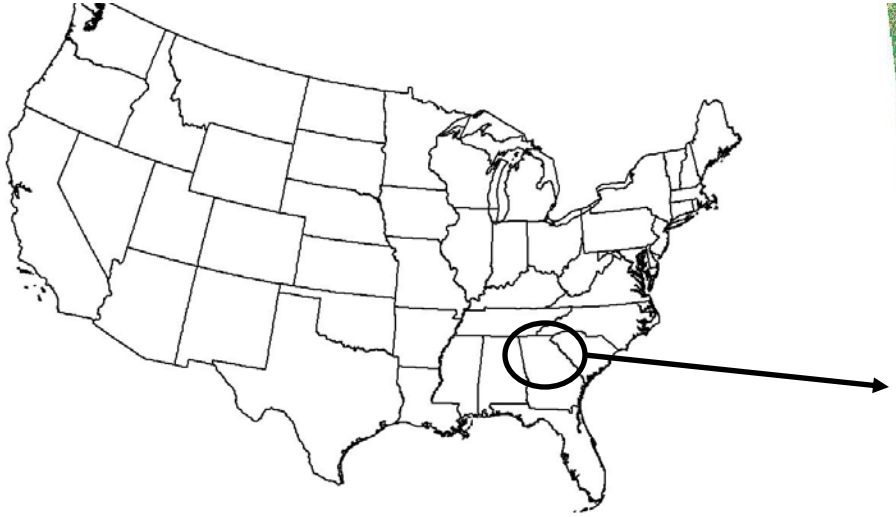
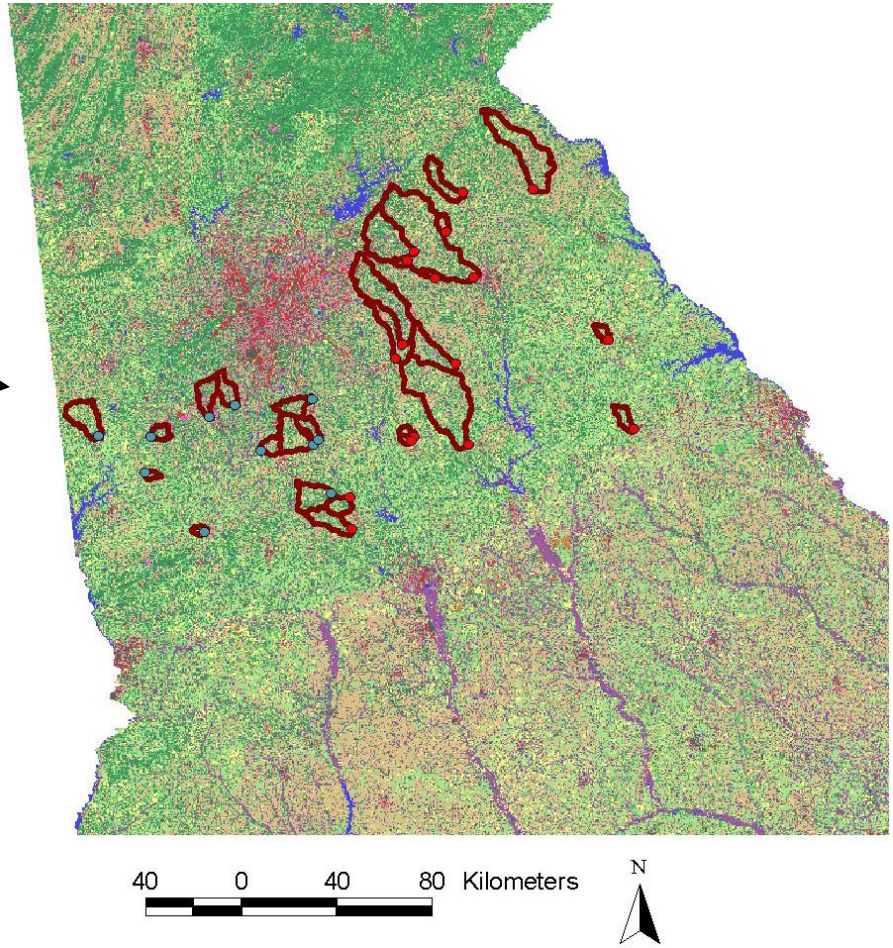
Municipal water withdrawals – lower Piedmont, GA





Land cover based on 1998 Landsat TM Imagery (*UGA 2001)*

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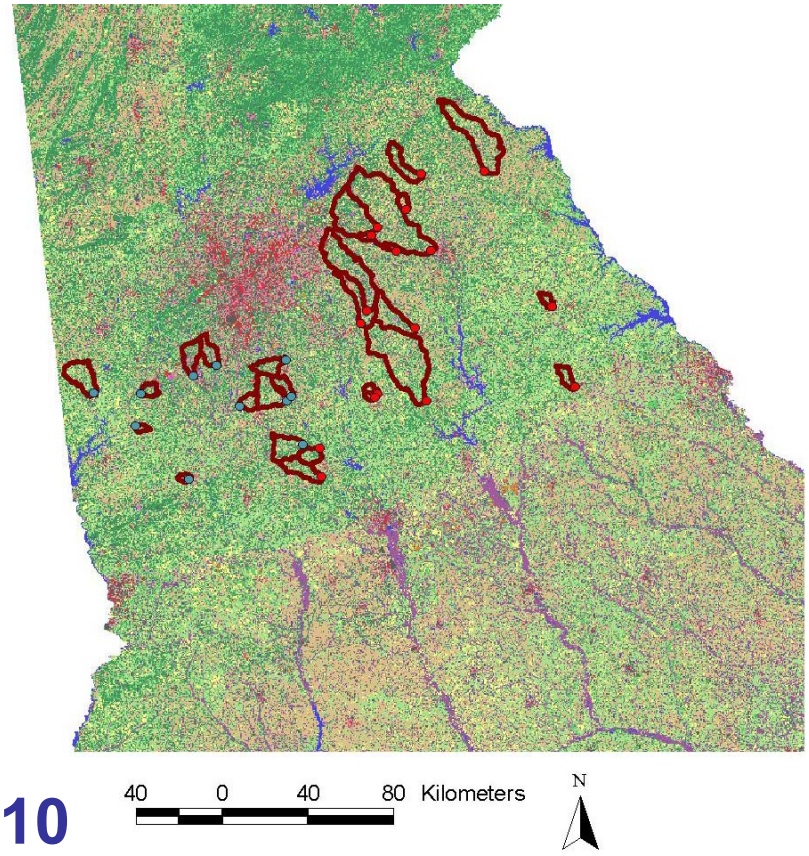
Municipal water withdrawals – lower Piedmont, GA

- **27 sites with wadeable lotic habitat**

Watershed size	**14 – 1010 km^2**
Permitted max. monthly withdrawal	**0.4 – 12 mgd**
"Withdrawal Index"	**0.02 - 13.3 X 7Q10**



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Withdrawals are of two types:

Directly from the stream, "Intake sites" (n=14)

Or from a reservoir built on the stream, "Reservoir sites" (n=13)

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Research questions:

Do fish assemblages vary in relation to potential for flow-alteration by water withdrawal?

- ***higher permitted withdrawal levels***
- ***withdrawals from instream reservoirs vs. intakes***

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Methods:

- Sampled fishes downstream from intakes/reservoirs; June-September
- 1-pass, electrofishing
    - reach length = 35X channel width (GA DNR Protocol)
- Habitat measures
- 2000, n = 26 sites
- 2001, n = 26 sites
- 2003, n = 20 sites

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Stream Flow (at time of sampling):

Discharge (X 7Q10)

	2000	2001	2003
Intakes	0.62	3.22	7.41
Reservoirs	0.62	3.92	9.30
DNR Reference sites	1.35	-	-

- *Averaged < 7Q10 in 2000*
- *> 10X higher in 2003*
- *Similar between intake and reservoir sites*

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Analyses

- **Relate richness of two species groups to withdrawal level and type**
  - "fluvial-specialists"
  - "habitat-generalists"

- **Ordination of catch data**
  - differences between large and small withdrawals? Intake and reservoir sites?

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Assemblage components:

Family		Fluvial specialists (n=47)	Habitat generalists (n= 40)
Cyprinidae	*Minnows*	**22**	5
Catostomidae	*Suckers*	**10**	1
Ictaluridae	*Catfishes*	3	8
Centrarchidae	*Sunfishes, basses*	4	**13**
Percidae	*Darters, yellow perch*	**5**	2
Others		3 *	11 **

* Petromyzontidae *Lampreys*, Fundulidae *Topminnows*, Cottidae *Sculpins*

** Lepisosteidae *Gars,* Amiidae *Bowfins*, Anguillidae *Eels*, Clupeidae *Shads,* Esocidae *Pickerels,* Aphredoderidae *Pirate perch*, Atherinopsidae *Silversides,* Poeciliidae *Mosquitofish,* Moronidae *Temperate basses*

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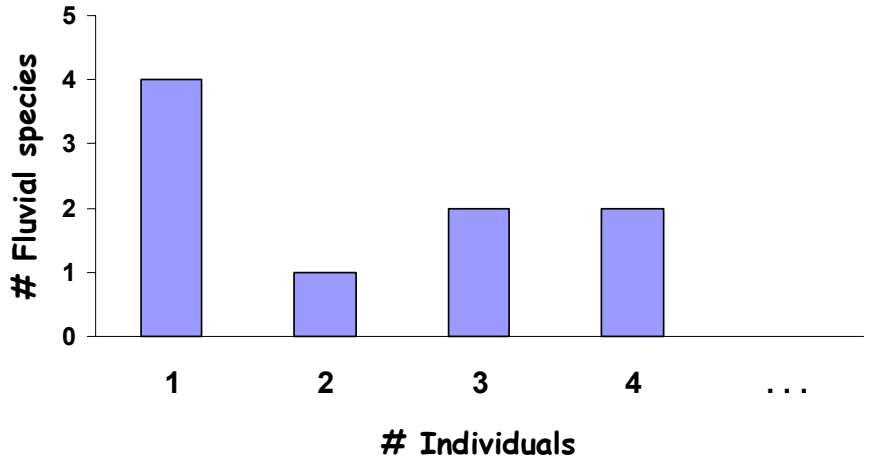
Analyses

Estimated species richness: 1st-order jackknife estimator, limiting form M_h



Reduce bias from incomplete detectability and species differences in detectability
(Burnham and Overton 1979, Williams et al. 2002)

1st-order jackknife estimator

$$N\text{-}hat_{fs} = S + f_1$$

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Analyses

Evaluated relative support for alternative linear regression models of species richness versus:

- **Drainage area**
- **Withdrawal level - *WI***
- **Withdrawal type (reservoir or intake)**
- **Land use - *% urban upstream of site* (0 – 12 %)**
- **Instream habitat - *modal bed sediment (phi*: *sand to cobble)***

Information-theoretic approach to evaluate support for alternative models; Akaike's information criterion (AICc); 12-15 alternative models *(Burnham and Anderson 2002)*

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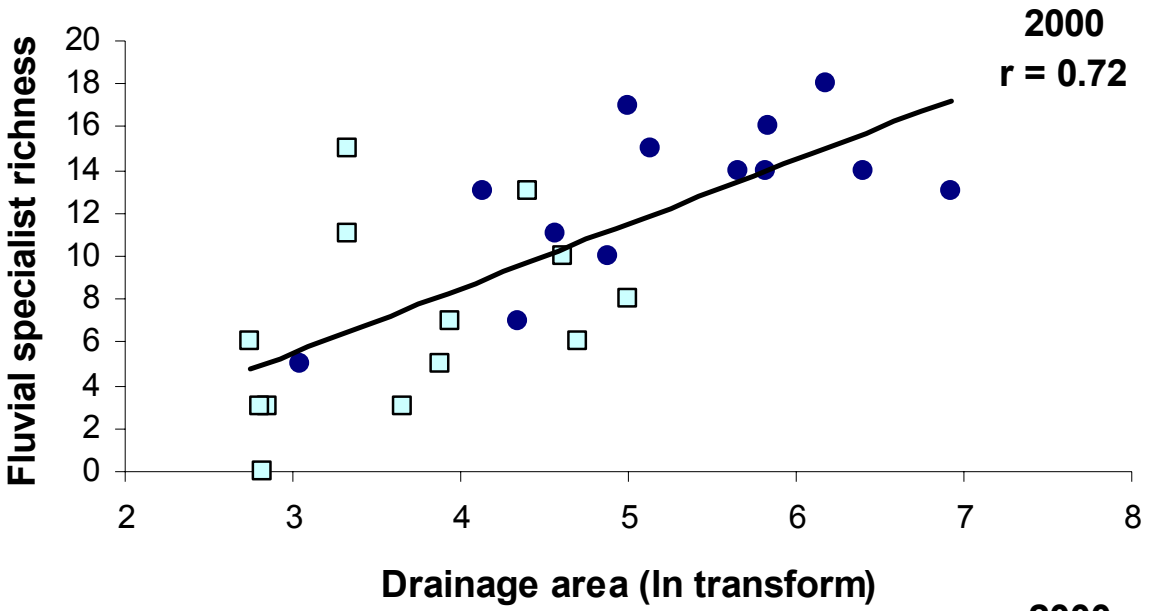
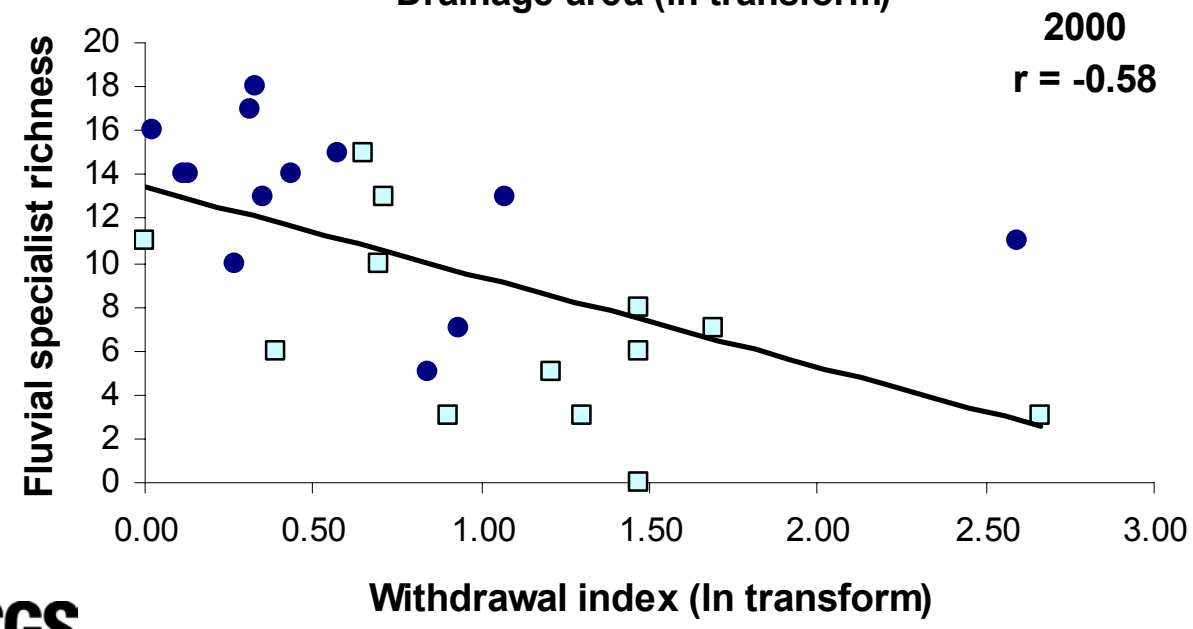
Results, Year 1, Fluvial Specialists





ln DA vs. ln WI:
r = - 0.44

Reservoirs

Intakes

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Best-supported models for fluvial specialists richness, 2000

Site variables	Δ_{AICc}	w_i	Adj. R^2
DA,	1.29	0.22	0.50
DA, WI	**0**	**0.42**	**0.55**
DA, Type	2.29	0.13	0.51
DA, phi	3.41	0.08	0.49
DA, %urban	4.09	0.05	0.48
WI, Type	4.34	0.05	0.51

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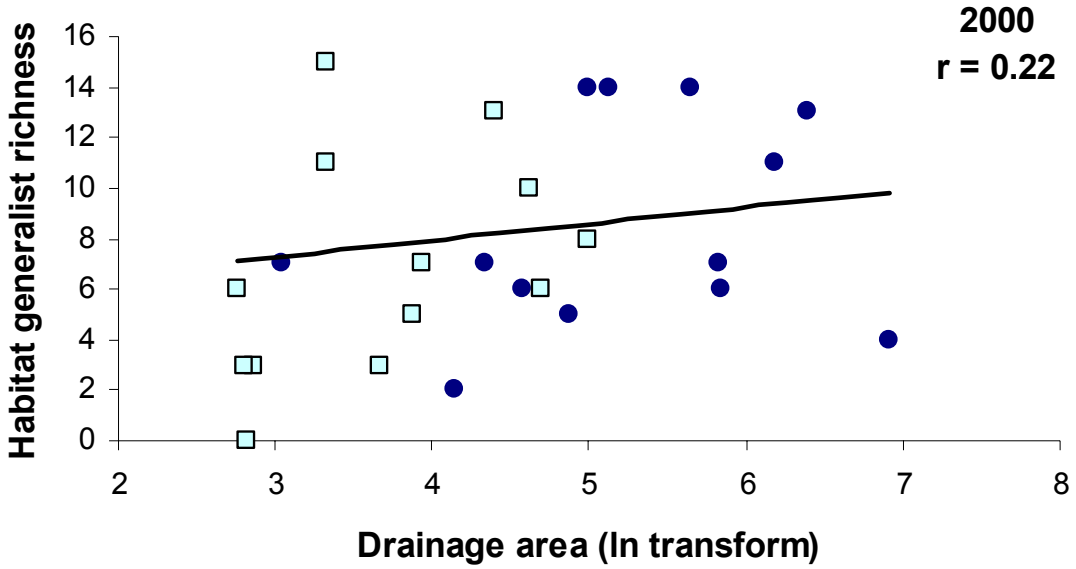
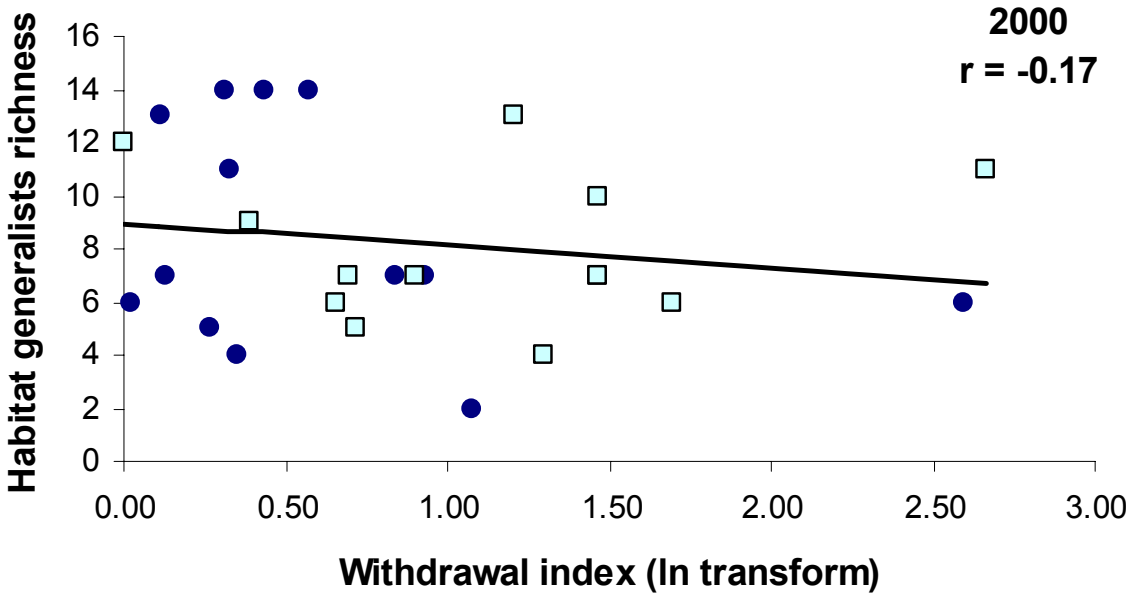
Results, Year 1, Habitat Generalists





Species richness not strongly related to any of the site variables

Reservoirs

Intakes

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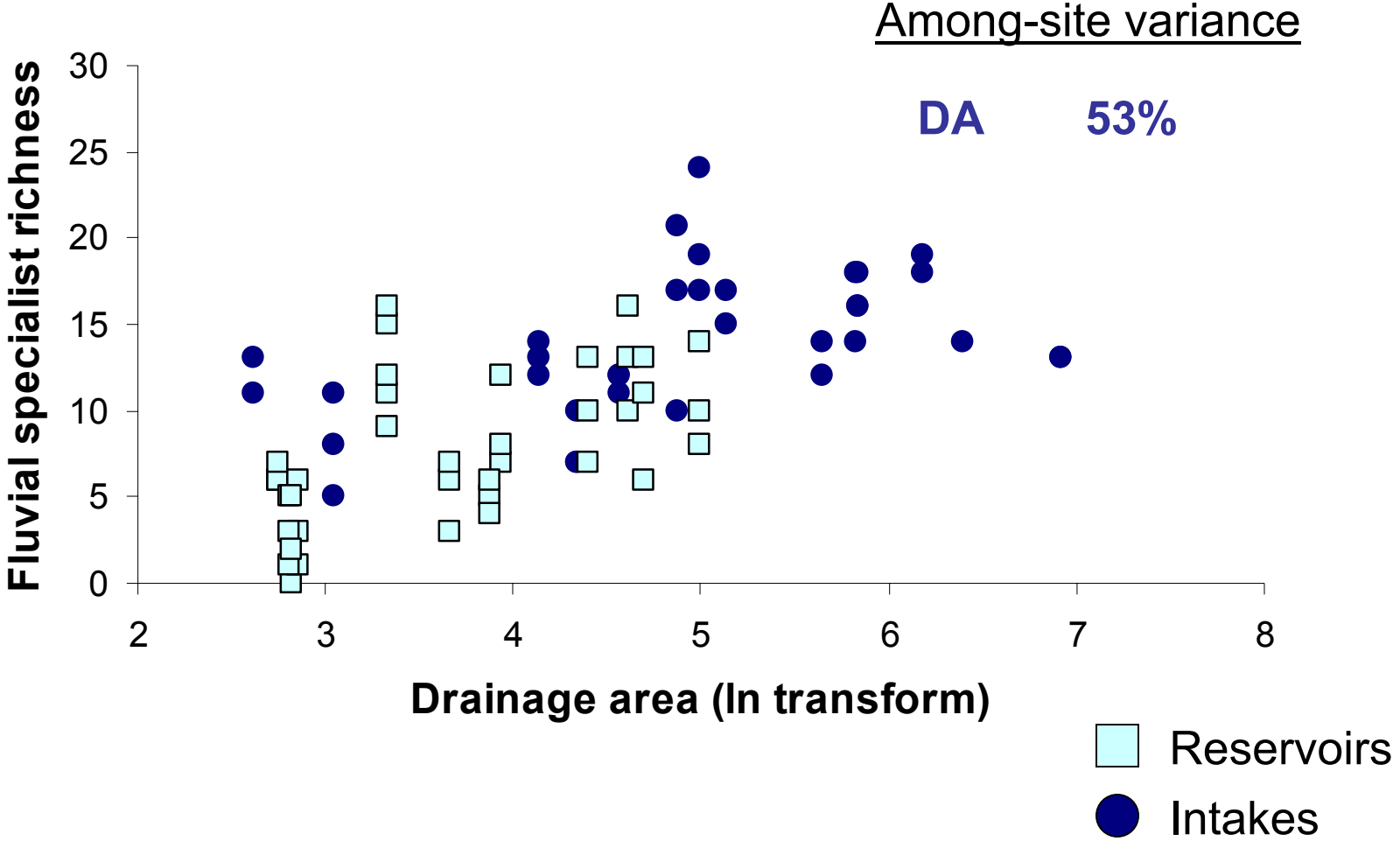
Three study years combined,
Fluvial specialist richness:
76% of the variance attributable to among site differences



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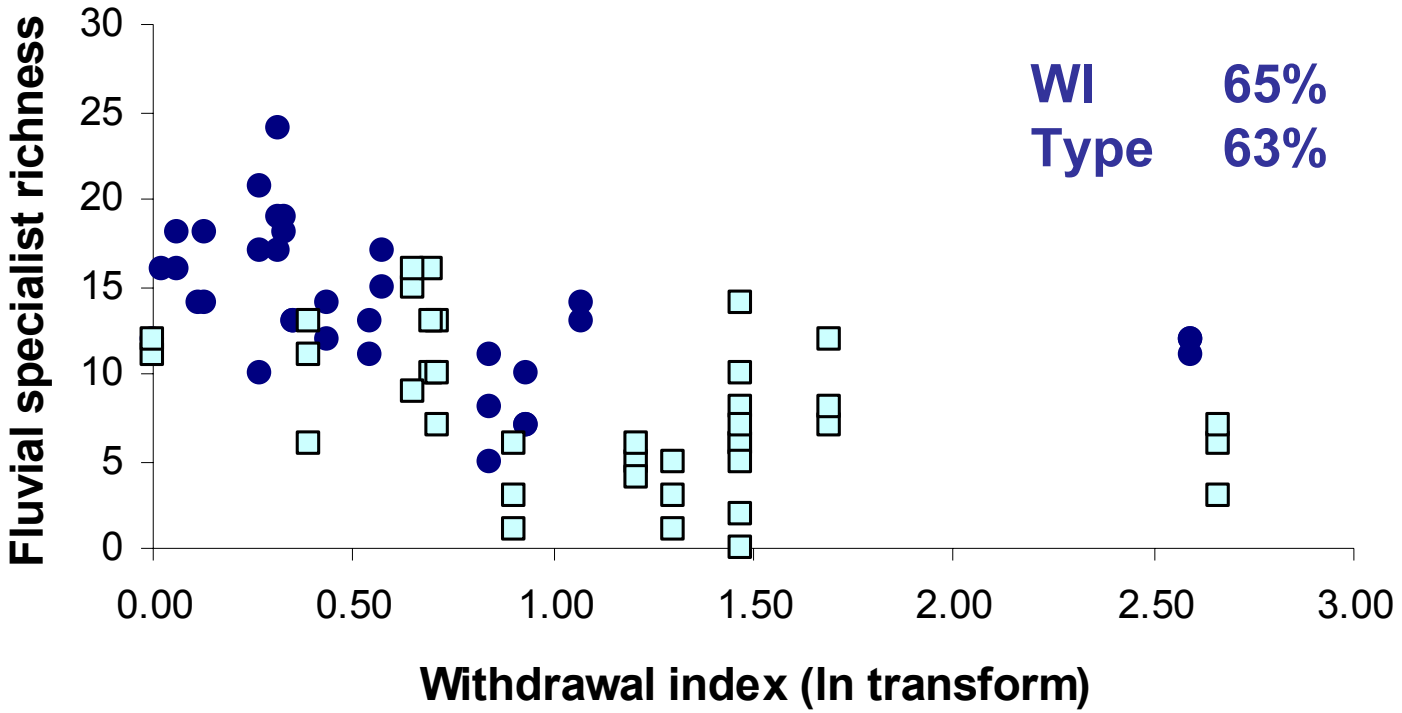
Three study years combined, Fluvial specialist richness

Among-site variance

WI 65%
Type 63%



Reservoirs
Intakes

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Best-supported models for fluvial specialists richness, all years, nested in sites

Site variables	Δ_{AICc}	w_i	Among-site variance
DA, WI	2.5	0.10	65%
DA, Type	1.9	0.14	63%
DA, WI, Type	**0**	**0.35**	**70%**
DA, WI, Type, *phi*	2.4	0.11	69%
DA, WI, Type, %urban	2.5	0.10	69%
DA, WI, Type, min Q	2.3	0.11	69%

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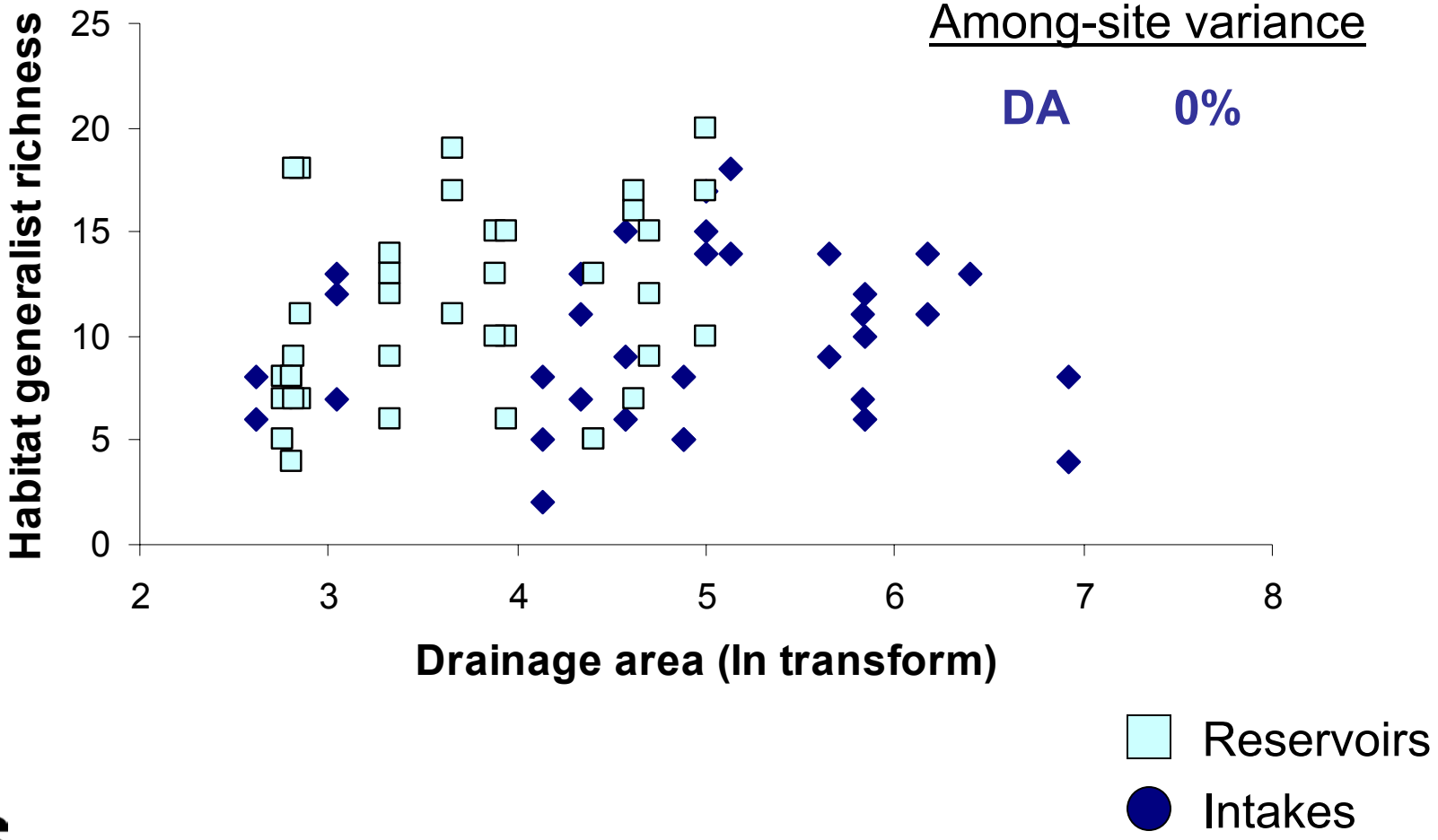
Three study years combined,
Habitat generalist richness:
27% of the variance attributable to among site differences



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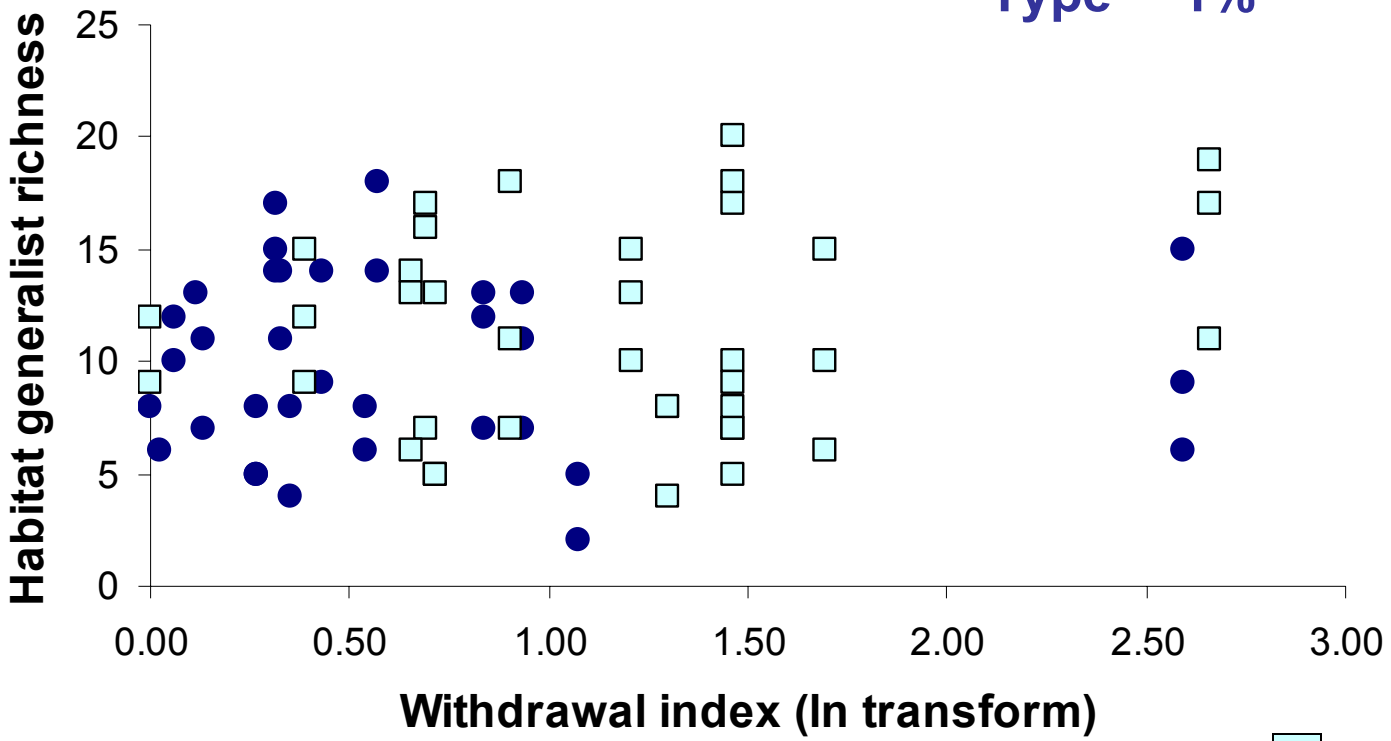
Three study years combined,
Habitat generalist richness:

Among-site variance

WI	**0%**
Type	**1%**



Reservoirs

Intakes

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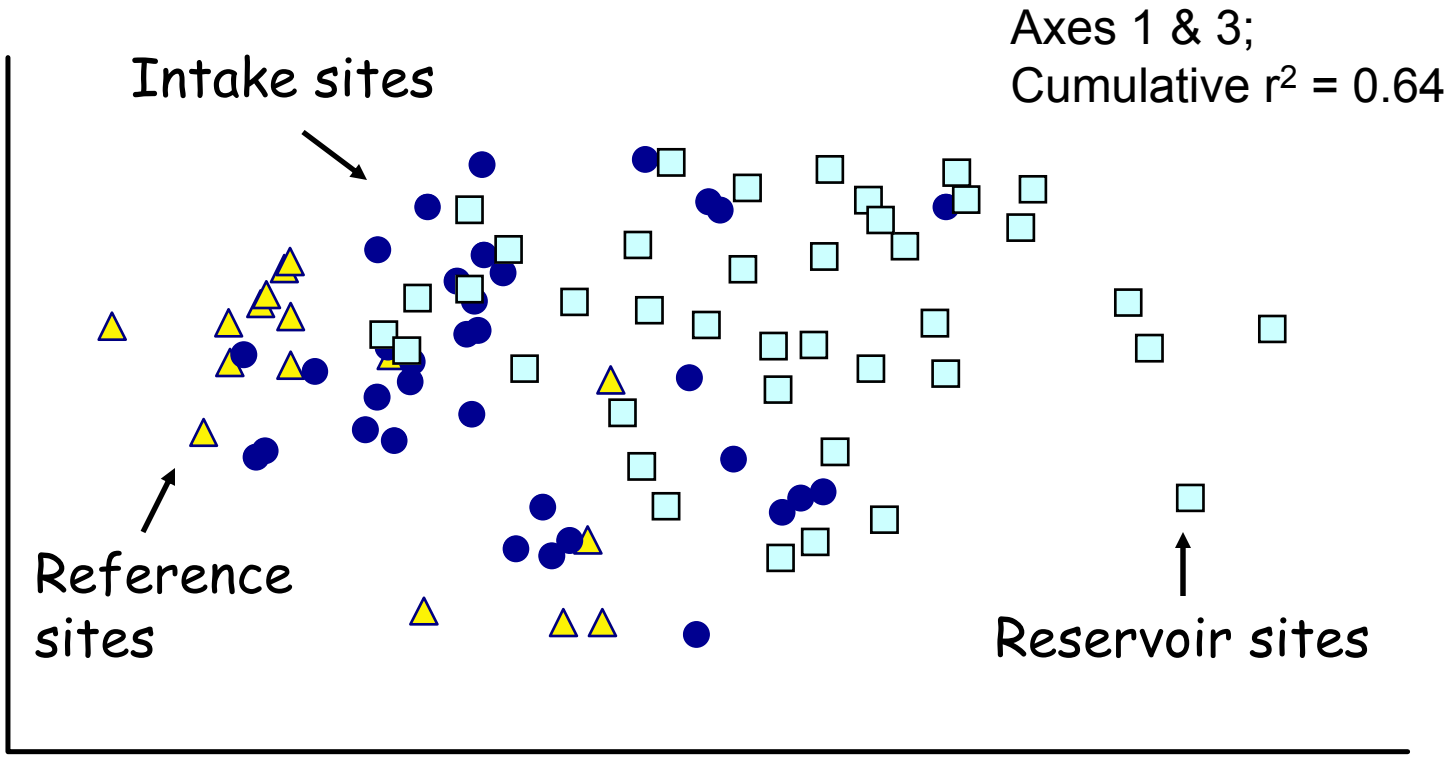
NMDS ordination of catch data: all years



Cyprinella spp. (0.81)
Hybopsis spp. (0.57)
Notropis hudsonius (0.61)

Scartomyzon spp. (0.67)
Moxostoma spp. (0.68)
Noturus spp. (0.63)
Percina nigrofasciata (0.75)

Micropterus spp. (0.62)
Lepomis auritus (0.59)

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Management implications:

Based on 3 yr study in streams of the lower Piedmont, GA

- Increasing the capacity for flow alteration reduces stream's capacity to support stream-dependent species
- Effects not restricted to drought conditions
- Supplying water with
  - *instream reservoirs* or
  - *withdrawals that are large relative to stream size*

is likely to lead to loss of stream-dependent species

(but habitat generalists may not be affected)

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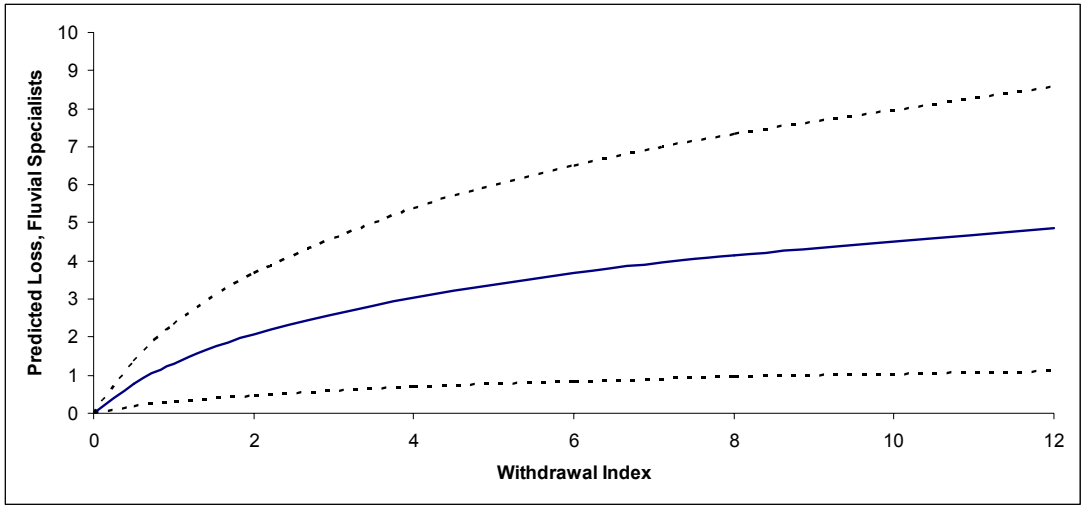
Predicted loss of fluvial specialists?

Model-averaged estimates of effect sizes*:

Effect	Mean (SE)	90% Confidence Interval
In WI	-1.89 (0.87)	-0.44 to -3.35
Reservoir	-3.06 (1.33)	-0.83 to -5.30



Predicted species loss, 90% confidence limits*

**based on 3 yr study in streams of the lower Piedmont, GA*

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Management Questions

Instream Flow policy:

How much flow is needed to protect integrity of stream assemblages?

Need to know Mechanisms: flow-biota	→	To design Flow specifications

"Ecological safe-yield" approach:

How much can flow regimes be altered without compromising biotic integrity?

Can use empirically derived relations in an adaptive management approach to water supply development

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Average depths and velocities:

- Also similar between intakes and reservoirs

	2000	2001	2003
Depth (m)			
Intakes	0.28	0.42	0.36
Reservoirs	0.28	0.34	0.35
Reference sites	0.24	-	-
Velocity (m/s)			
Intakes	0.07	0.15	0.17
Reservoirs	0.04	0.09	0.17
References	0.07		

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