A comparison of coho salmon (*Oncorhynchus kisutch*) abundance and land use in the Georgia Basin, British Columbia

Maria Morlin, Zoology, UBC

Fisheries Centre

Outline

- Problem
- Question
- Objectives
- Data
- Analysis
- Results
- Summary

Problem - massive coho population declines

- Coho have declined by ~ 90% since late 1970's
- Habitat loss, overfishing, marine survival
- What are relative contributions?
- Importance: research effort and public funds directed proportionately

- **Question** What is the impact of habitat change on coho and could it explain population declines?
- **Hypothesis** Habitat change has not contributed to coho population declines

Objectives

- **Determine whether land use can explain *spatial* variation in coho fry and adult escapement**
- **Determine impact of land use *change* on coho over 40- and 20-year time series**
- **Determine whether stream characteristics are useful in predicting coho abundance**

Coho life history

Eggs hatch in spring

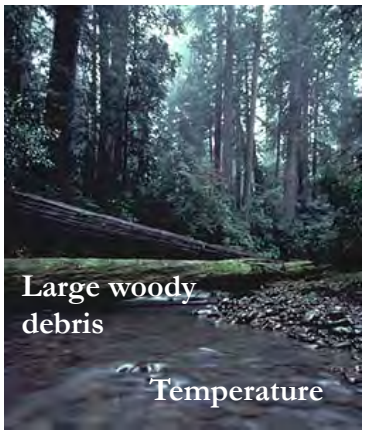
Rear in streams~1yr

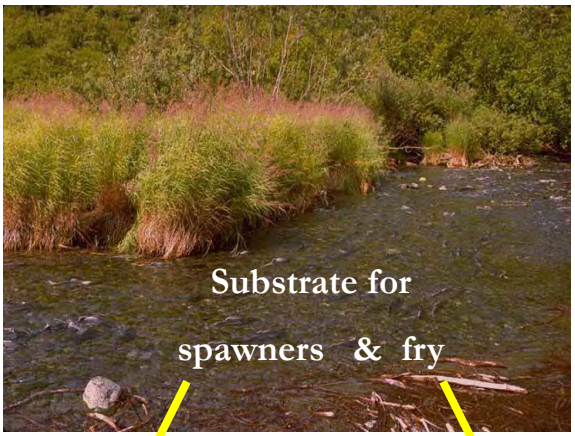
18 months at sea

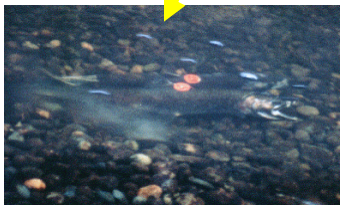
Spawn in the fall

FRESHWATER PHASE


Low-
velocity
Pools


Large woody
debris
Temperature


Substrate for
spawners & fry



nutrients

Land use affects streams by ...

- Soil compaction → drainage → flow regime velocity
- Logging, clearing for housing development → large woody debris, temperature and siltation
- Agriculture → manure → eutrophication

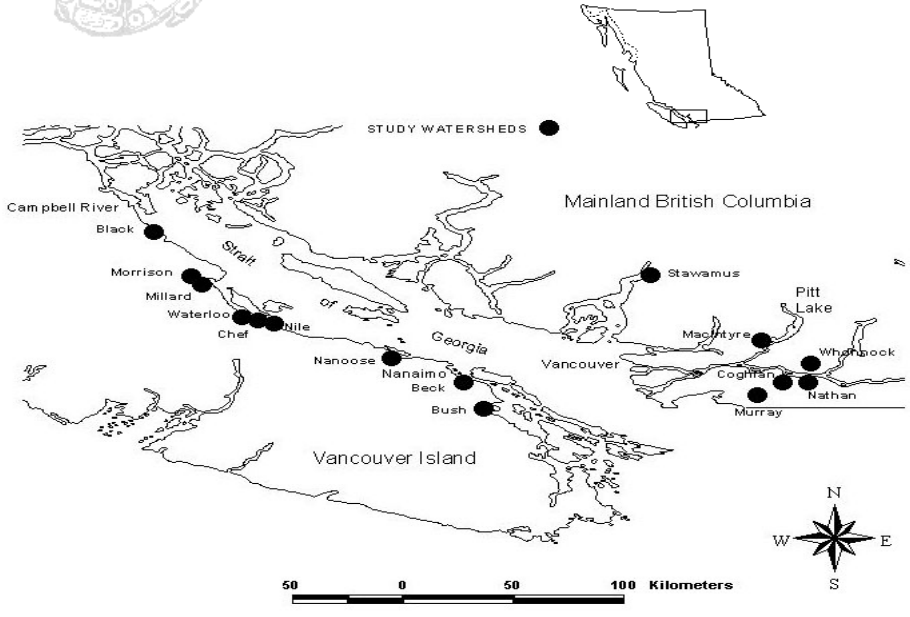
Oliver Creek

Portuguese Creek

Land use as an indicator of habitat change

- Land use can affect stream characteristics
- Habitat change is difficult to measure or date
- Historical aerial photographs provide consistent land use coverage

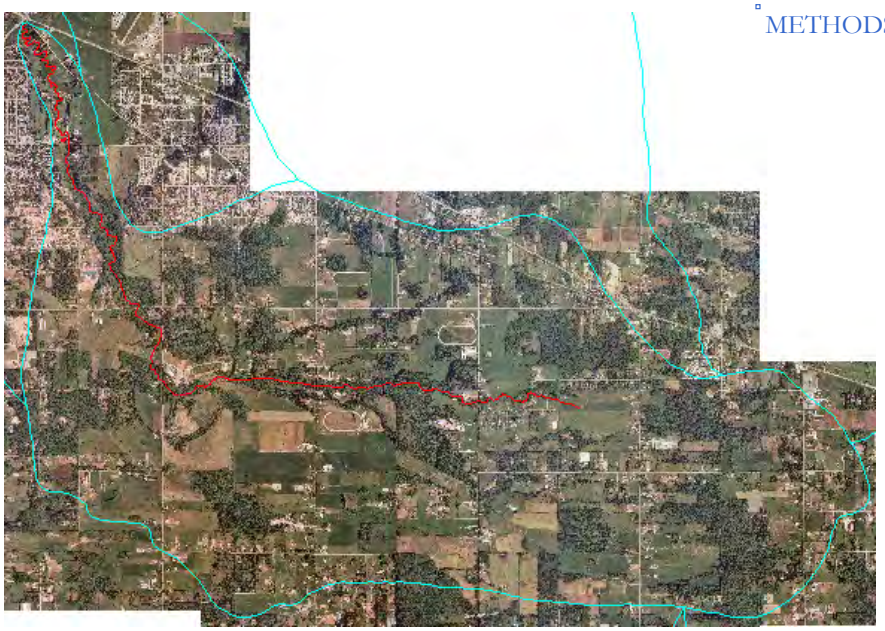
Study watersheds



Data

- Land use
- Coho fry
- Adult escapement

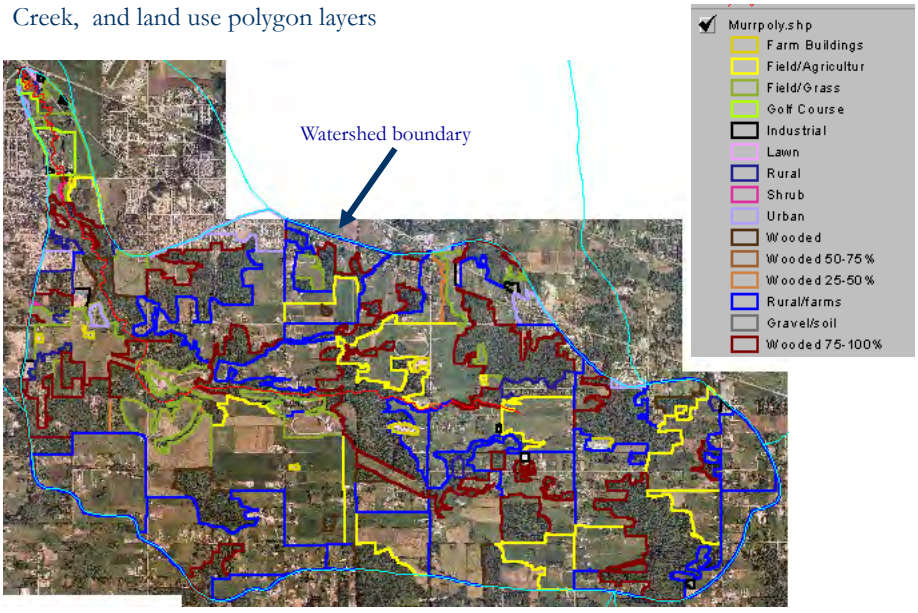
METHODS



Watershed boundary, Murray Creek

METHODS

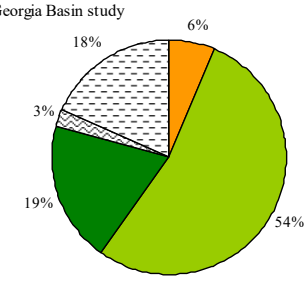
Fig. 1 Murray Creek watershed 1995 orthophotos, Murray Creek, and land use polygon layers



Land use classifications

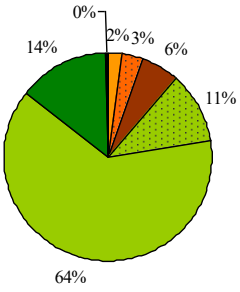
- **Broad land use**
  - **High use (urban, industrial, roads, rural)**
  - **Medium use (agriculture, small farms, pasture)**
  - **Low use (forested)**
- **Impervious land use - soil compaction/water storage**
  - **High (paved areas)**
  - **Very low (old growth)**

Georgia Basin study

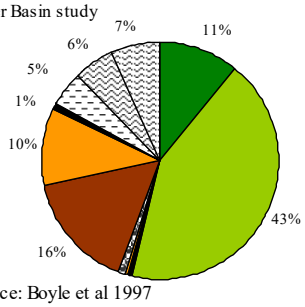


Source: Mulholland 1996

Study watersheds: Georgia Basin

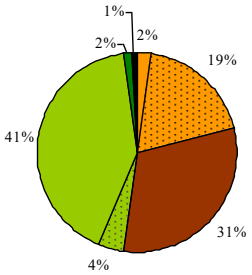


Fraser Basin study



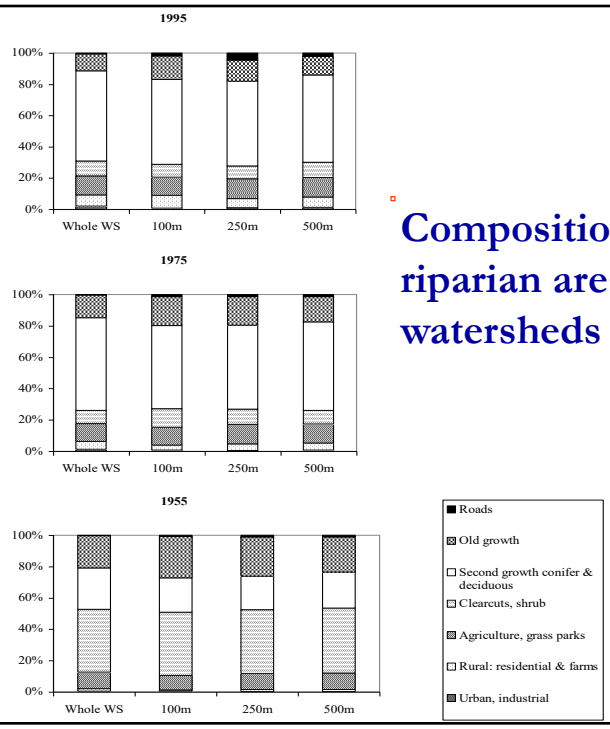
Source: Boyle et al 1997

Study watersheds: Fraser Basin



METHODS

Composition land use in riparian areas and whole watersheds



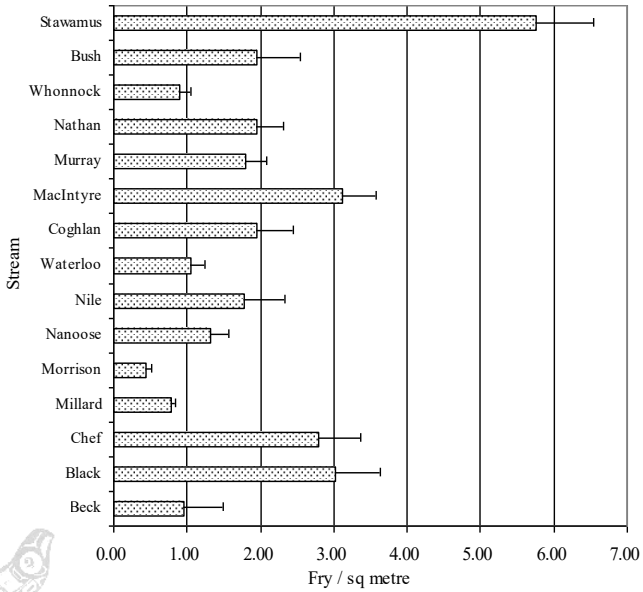
METHODS

Coho data

- Coho fry counts
  - Department of Fisheries and Oceans (DFO)
  - Annual 2- or 3-pass removal surveys (Aug/Sept)
  - Seine nets & electroshocking
- Coho escapement
  - DFO
  - Annual visual stream surveys
  - Indicator creeks: fence counting & mark-recapture

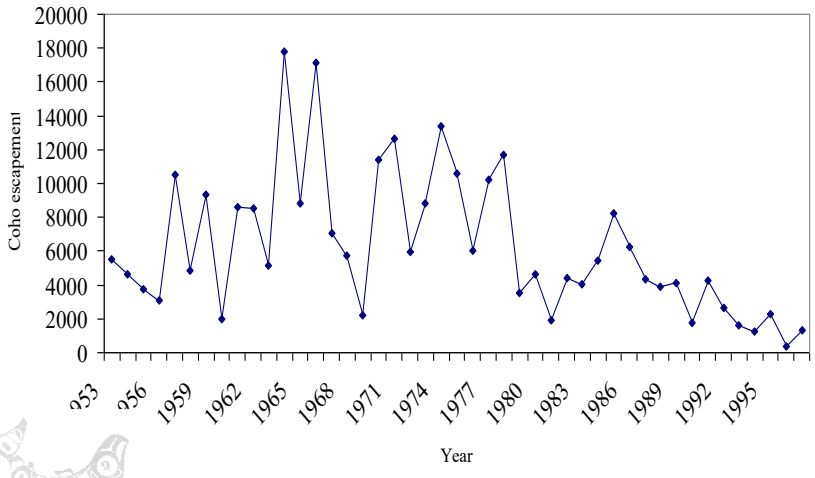
METHODS

• Coho fry mean densities (1991-1997)



METHODS

• Coho adult escapement 1953-1997 for combined sites



METHODS

- Spatial analysis: mean escapement for three decadal time periods

- Temporal analysis: realized rate of population growth (g)

$$N_t = N_o e^{gt}$$

Statistical analyses

METHODS

1. Can land use explain *spatial* variation in coho fry and adult escapement?

Linear regressions:

Coho fry densities on land use (15 watersheds) in 1995

Mean adult escapement on land use (15 ws) (1955, 1975, 1995)

2. Can land use *change* explain variation in coho fry and *temporal* variation in adult escapement?

Linear regressions:

Coho fry densities on land use change (2 time series)

Population growth rate (g) on land use change (2 time series)

Statistical analyses

METHODS

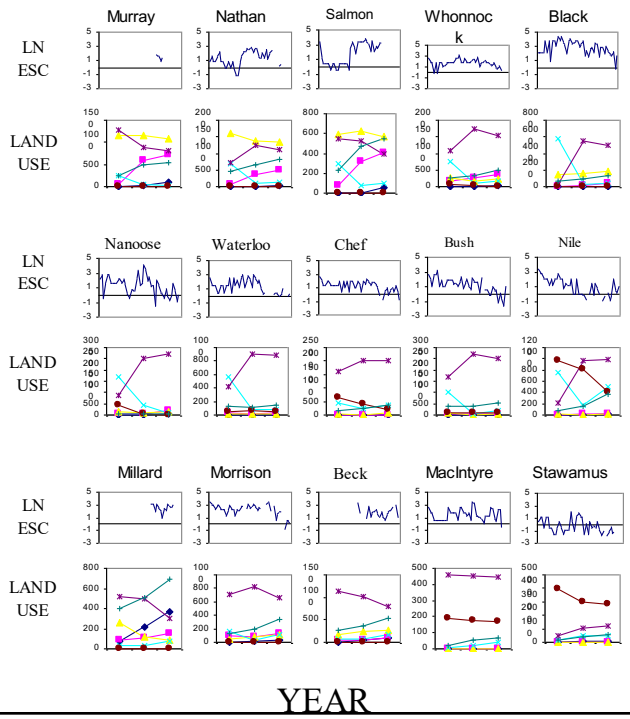
3. Can stream attributes (gradient, temperature, conductivity and sinuosity) explain *spatial* variation in coho fry and adult escapement?

Linear regressions:

Coho fry densities on stream attributes (1995)

Mean escapement (1990-1997) on stream attributes (1995)

RESULTS



RESULTS

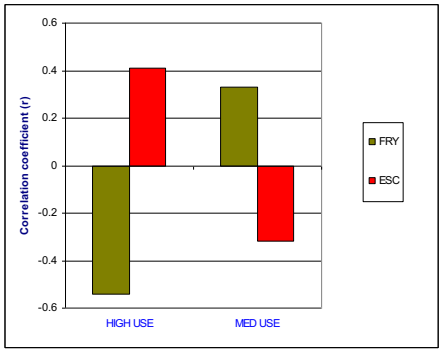
• Spatial analysis: broad land use

		BROAD LAND USE					
Coho		Agriculture	Urban	Forested	Second growth	Old growth	Clearcut & shrub
Mean fry	r	0.00	-0.60*	+0.33	-0.24	+0.74*	0.00
1991-1997	p	0.84	0.02 (ns)	0.24	0.40	**0.0015****	0.10
	pw	0.05	0.70	0.21	0.13	0.98	0.05
Mean esc.	r	0.00	+0.45*	-0.35	-0.40	0.00	+0.22
1990-1997	p	0.85	0.10	0.21	0.14	0.88	0.41
	pw	0.05	0.38	0.23	0.31	0.05	0.12
Mean esc.	r	-0.36	-0.17*	+0.33	+0.14	+0.24	+0.44
1970-1985	p	0.18	0.54	0.22	0.63	0.39	0.11
	pw	0.26	0.07	0.22	0.07	0.13	0.36
Mean esc.	r	-0.70	-0.17*	0.00	-0.41	+0.40	+0.37
1953-1965	p	0.0113 (ns)	0.57	0.91	0.18	0.20	0.23
	pw	0.80	0.08	0.05	0.26	0.24	0.21

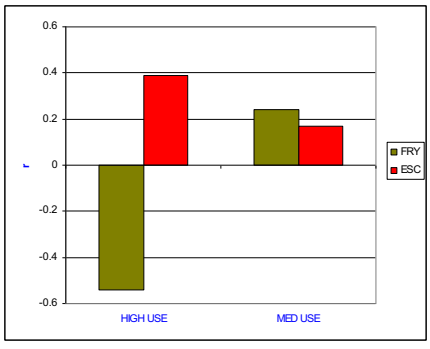
RESULTS

• Temporal analyses: percent broad land use *change*

(20 years - post-1975)

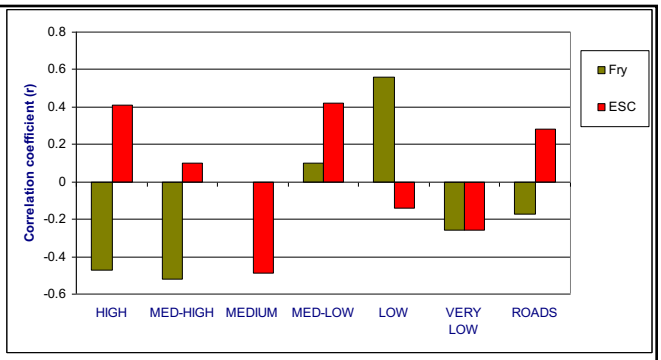


(40 years - 1955-1995)

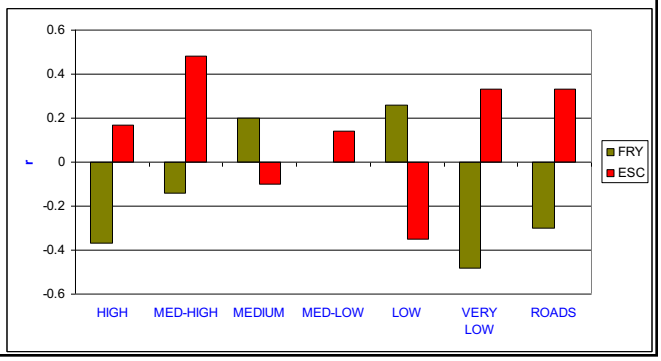


- **Temporal analyses: impervious land use *change***

(20 years)

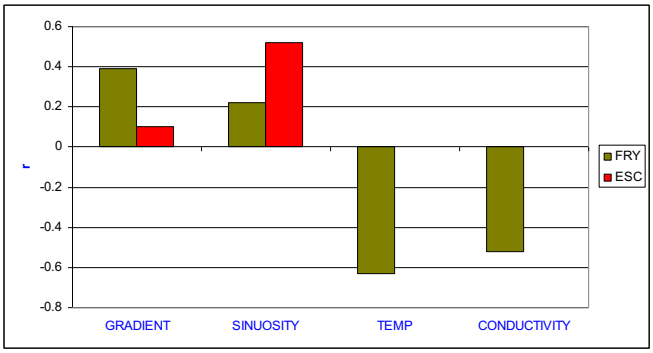


(40 years)



RESULTS

Coho fry and mean escapement on stream attributes: 1995



SUMMARY

- No strong *temporal* relationships
- Weak *spatial* relationships:
  - Urban/industrial land use & coho fry (1995)
  - Old growth & coho fry (1995)
  - Agriculture & escapement (1955)
  - Temperature and coho fry (1995)

Conclusions

- At the watershed scale, habitat effects appear to have had little contribution toward coho declines
- Fry showed a weak response to land use - escapement response may be delayed.

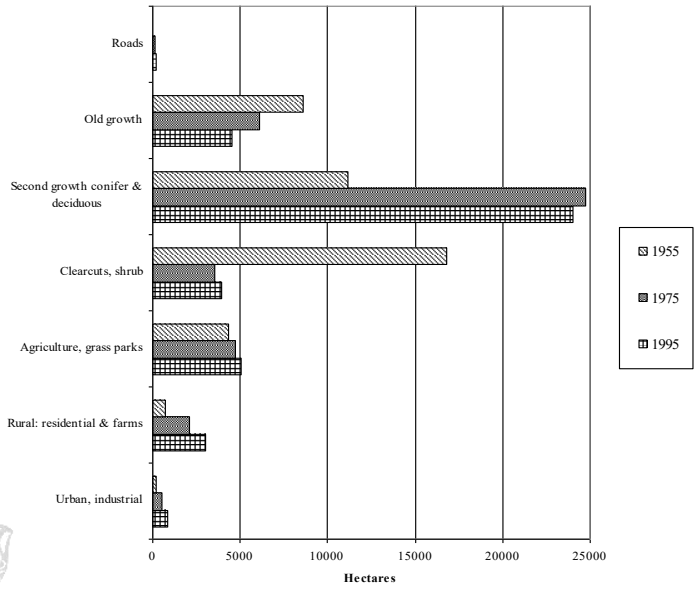
Acknowledgements

- Carl Walters, Scott Hinch
- Department of Fisheries and Oceans:

  Kent Simpson, Blair Holtby, Gary Logan, Brad Mason
- Ernest Keeley, Dan Reinders, Dale Kolody, Karl Vernes, Brian Klinkenberg, Hans Schreier, Les Lavkulich,Marc Porter, Warwick Browne
- Fellow grad students
- Ministry of Fisheries

RESULTS

Land use change (combined WS's)



Discussion

- Coho may be resilient to habitat alteration
- Georgia & Lower Fraser basin rate of development
- Other land use types not considered in this study
- Effect size

- **Comparison: temporal variation in land use with coho fry and coho escapement (g)**

40-year time series 1955-1995				
		RESULTS		
BROAD LAND USE Urban, agriculture, forested	Coho escapement (g)	0	r	p
	Coho fry (density)	Urban	-0.54	.04
IMPERVIOUS LAND USE Six impervious categories	Coho escapement (g)	0		
	Coho fry (density)	0		
20-year time series post-1975				
			r	p
BROAD LAND USE Urban, agriculture, forested	Coho escapement (g)	0		
	Coho fry (density)	Urban	-0.54	.04
IMPERVIOUS LAND USE Six impervious categories	Coho escapement (g)	0		
	Coho fry (density)	Forest	+0.56	.03

Comparison: riparian land use, coho fry and escapement (g) temporal variation

40-year time series 1955-1975					
	buffer		Correlations	r	p
BROAD LAND USE	100 metre	Coho escapement (g)	0		
		Coho fry (density)	High (hard)	-0.66	0.009
	250 metre	Coho escapement (g)	Urban	+0.57	0.02
		Coho fry (density)	Urban	-0.54	0.04
	500 metre	Coho escapement (g)	Urban	+0.51	0.05
		Coho fry (density)	Urban	-0.50	0.05

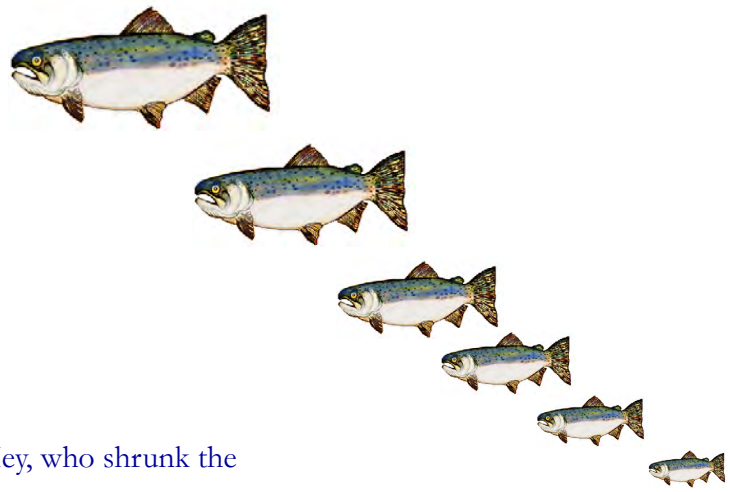
20-year time series post-1975					
	buffer			r	p
IMPERVIOUS LAND USE	100 metre	Coho escapement (g)	0		
		Coho fry (density)	High (hard)	-0.66	0.009
	250 metre	Coho escapement (g)	0		
		Coho fry (density)	High (hard)	-0.68	0.011
	500 metre	Coho escapement (g)	0		
		Coho fry (density)	0		

Comparison: spatial variation of land use, coho fry and escapement across watersheds at 3 time periods

	Date		Correlations	r	p
BROAD LAND USE	1991-1997	Coho fry (density)	Urban Old growth	-0.60 +0.74	0.02 0.002
	1990-1997	Coho mean escapement	0		
	1970-1985	Coho mean escapement	0		
	1953-1965	Coho mean escapement	Agriculture	-0.70	0.01

Comparison of stream physical characteristics and spatial variation in coho fry density and mean escapement

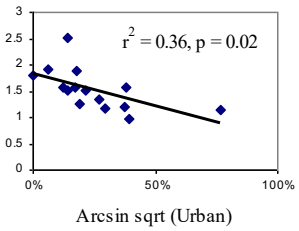
Stream attribute		Correlations	r	p
Mean gradient (%)	Coho fry (density)	0		
	Mean escapement	0		
Mean sinuosity	Coho fry (density)	0		
	Mean escapement	0		
Mean temperature (°C)	Coho fry (density)	Yes	-0.63	0.02
	Mean escapement	0		
Conductivity (microsiemens)	Coho fry (density)	0		
	Mean escapement	0		



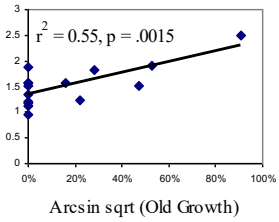
Hey, who shrunk the salmon?

Linear regression: coho fry and escapement on proportion land use (impervious grouping)

			Percent change impervious land use 1975-1995						
Coho	Buffer Width (m)		High	Medium High	Medium	Medium Low	Low	Very Low	Roads
Fry	100 m	r	-0.66*	+0.14	0.00	-0.35	+0.44	-0.20	+0.1
		p	0.0094(ns)	0.62	0.99	0.21	0.10	0.47	0.72
		pw	0.59	0.08	0.05	0.24	0.37	0.11	0.06
(g)	100 m	r	+0.2	0.00	-0.47	+0.24	+0.32	-0.45	+0.40
		p	0.47	0.94	0.07	0.40	0.25	0.10	0.14
		pw	0.11	0.05	0.45	0.13	0.20	0.38	0.31
Fry	250 m	r	-0.68*	-0.10	0.00	-0.28	+0.47	-0.22*	+0.10
		p	0.0113(ns)	0.72	0.98	0.30	0.08	0.44	0.80
		pw	0.79	0.06	0.05	0.42	0.42	0.11	0.06
(g)	250 m	r	+0.22*	+0.10	-0.45	+0.30	+0.10	-0.22*	+0.57
		p	0.45	0.78	0.10	0.28	0.72	0.44	0.24
		pw	0.11	0.06	0.18	0.18	0.06	0.11	0.20
Fry	500 m	r	-0.47*	-0.26	0.00	-0.24	+0.52	-0.26*	+0.14
		p	0.09	0.32	0.82	0.36	0.05	0.36	0.63
		pw	0.40	0.16	0.06	0.14	0.52	0.14	0.07
(g)	500 m	r	+0.39*	+0.10	-0.41	+0.22	0.00	-0.17*	+0.26
		p	0.17	0.75	0.13	0.40	0.91	0.52	0.33
		pw	0.27	0.06	0.32	0.13	0.05	0.09	0.15

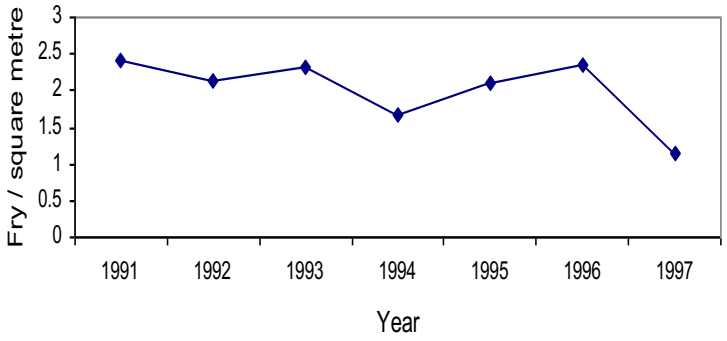


- Coho fry and urban land use



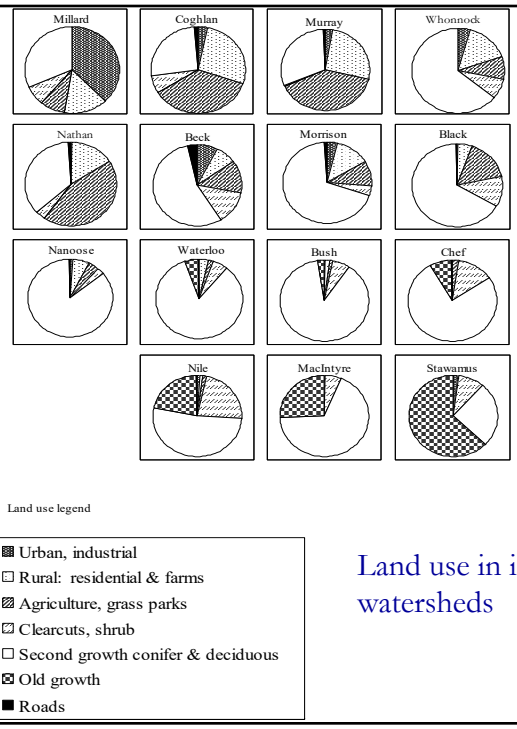
- Coho fry and old growth forest

Combined coho fry densities: 1991-1997



Linear regression: coho fry and escapement on proportion land use (impervious grouping)

		Percent change impervious land use 1975-1995						
Coho		High	Medium high	Medium	Medium low	Low	Very low	Roads
Fry	r	-0.47*	-0.52	0.00	+0.10	+0.56	-0.26*	-0.17
	p	0.11	0.05 (ns)	0.10	0.78	0.03 (ns)	0.35	0.53
	pw	0.36	0.53	0.05	0.06	0.61	0.15	0.09
(g)	r	+0.41	+0.10	-0.49	+0.42	-0.14	-0.26	+0.28
	p	0.12	0.71	0.06	0.12	0.66	0.32	0.30
	pw	0.34	0.06	0.47	0.34	0.07	0.16	0.17



Land use in individual watersheds

GIS: Geographical Information Systems

- Information system:
  - Chain of operations for acquisition, storage, analysis & communication of information
- GIS
  - The information is spatial or geographical in nature.
- Automated GIS
  - Application of computer technology to perform operations

GIS components

- Layers or coverages (image, lines, points, polygons)
- Spatial locations of objects (roads, buildings, land use polygons)
- Attributes of objects (road type, building type, classification & area of land use) = database

Purpose of study

- To investigate the relationship between coho abundance and land use

vs.

Millard Creek

Morrison Creek