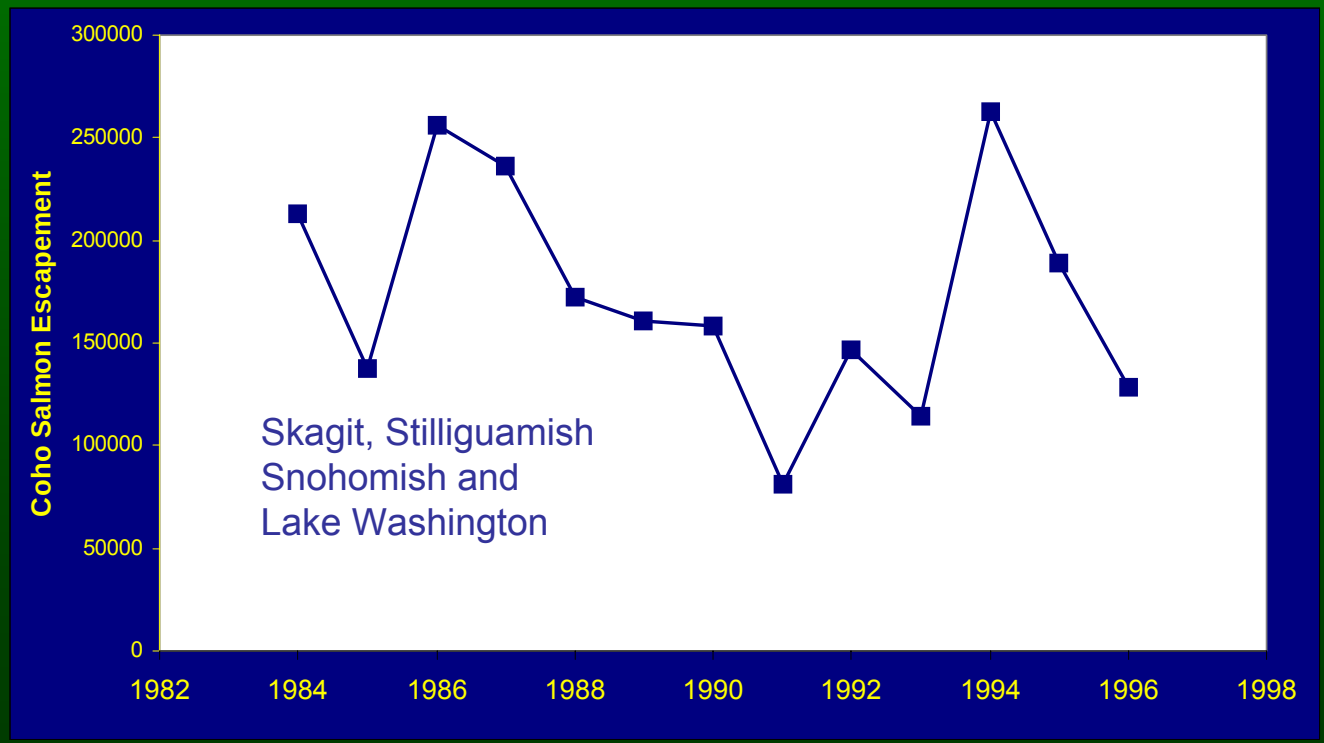
Effects of Development on Coho Salmon and Implications for Salmon Recovery

Robert E. Bilby and Lauren A. Villarin
Weyerhaeuser Co., Federal Way, WA

Do Changes in Land Use Affect Fish?

- Plenty of evidence of habitat impacts
- Relatively few examples for fish – especially adult salmon/steelhead
- Interannual variation in abundance impacted by out-of-watershed factors (e.g., marine conditions) – difficult to determine the contribution of changing freshwater habitat conditions



Problems in Assessing Fish Responses

- Lack of data on fish abundance
  - Study-specific juvenile abundance data, usually at a reach-scale
  - Long records of smolt production at few locations
  - Most consistently-collected data is on returning adult salmon – but difficult to relate to freshwater habitat conditions
- Adult abundance not reflective of freshwater habitat condition due to confounding effects of variable marine survival
- If freshwater habitat is an important determinant of population performance, should be reflected in the number of returning adults
- May be able to account for some variability due to changing marine conditions by examining changes in the distribution of spawning salmon rather than abundance

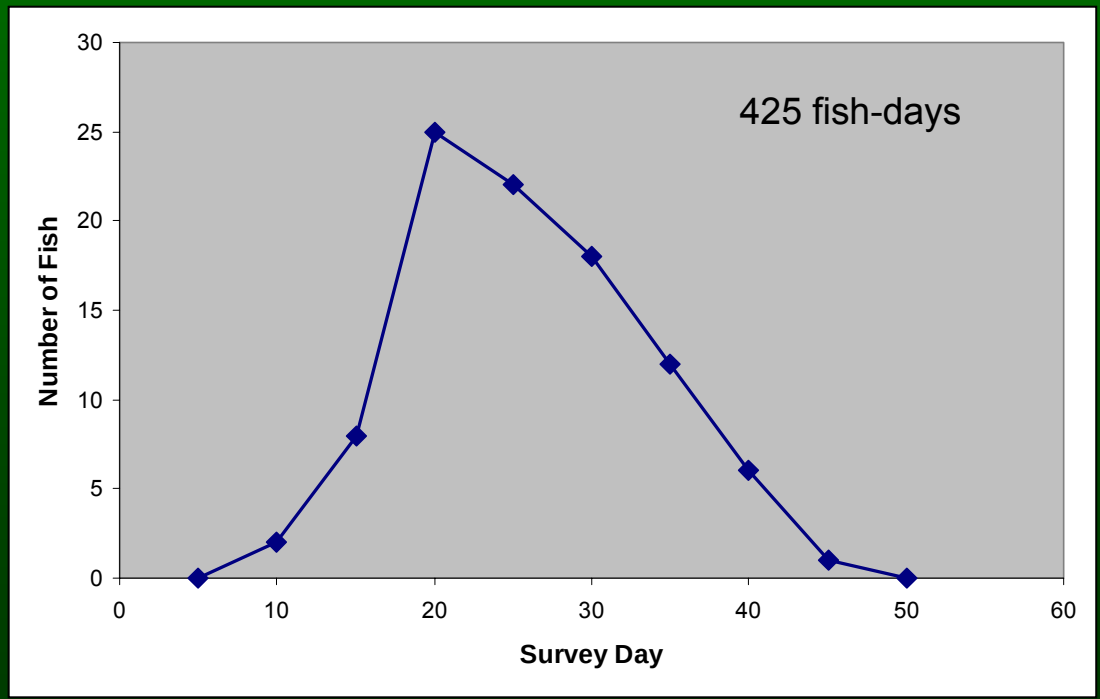
Does Changing Land Use Affect the Distribution of Returning Coho Salmon?

- Coho chosen because of available data and extended freshwater rearing
- Coho spawner index data (WDFW) from 4 basins – Skagit, Stilliguamish, Snohomish, Lake Washington
- Used index locations with annual data from 1984-2001
- Minimum of 3 surveys/yr
- 84 sites met the criteria
  - Skagit: 15
  - Stilliguamish: 18
  - Snohomish: 40
  - Lake Washington: 11
- Watershed area:

  10 ha - 2400 ha

Escapement Estimates

- "Area-Under the Curve" method
  - Assumes linear change in spawner abundance between survey dates
  - When first or last survey was not 0 fish, assumed 0 fish one week before or after survey date
  - Estimate of spawner abundance expressed as fish-days
- Annual fish-day estimates normalized for length of survey reach (fish-days/km)



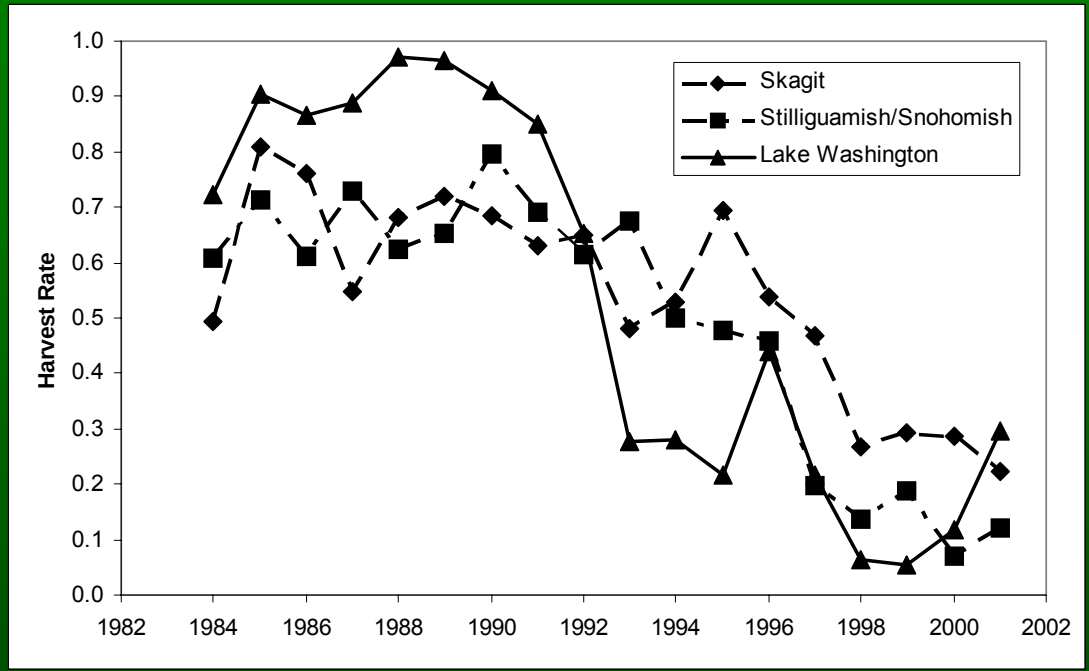
Exploitation Rates

Based on coded-wire tags*

Skagit
Skagit Hatchery and Baker Wild

Snohomish and Stilliguamish
Wallace River Hatchery

Lake Washington
L. WA Wild and Soos Cr. Hatchery



- Normalized fish-day estimates corrected for exploitation rate
- Correction to eliminate effects of differential harvest rates among basins
- Provides estimate of spawning fish at each index site in the absence of harvest

*CWT analysis provided by J. Haymes, WDFW

Spawner Distribution

- Use annual spawner abundance estimate for each index site to calculate the % of total abundance at all sites that each site supports each year
- Examine trend in % of spawners at a site over time
- Related trend to land use changes

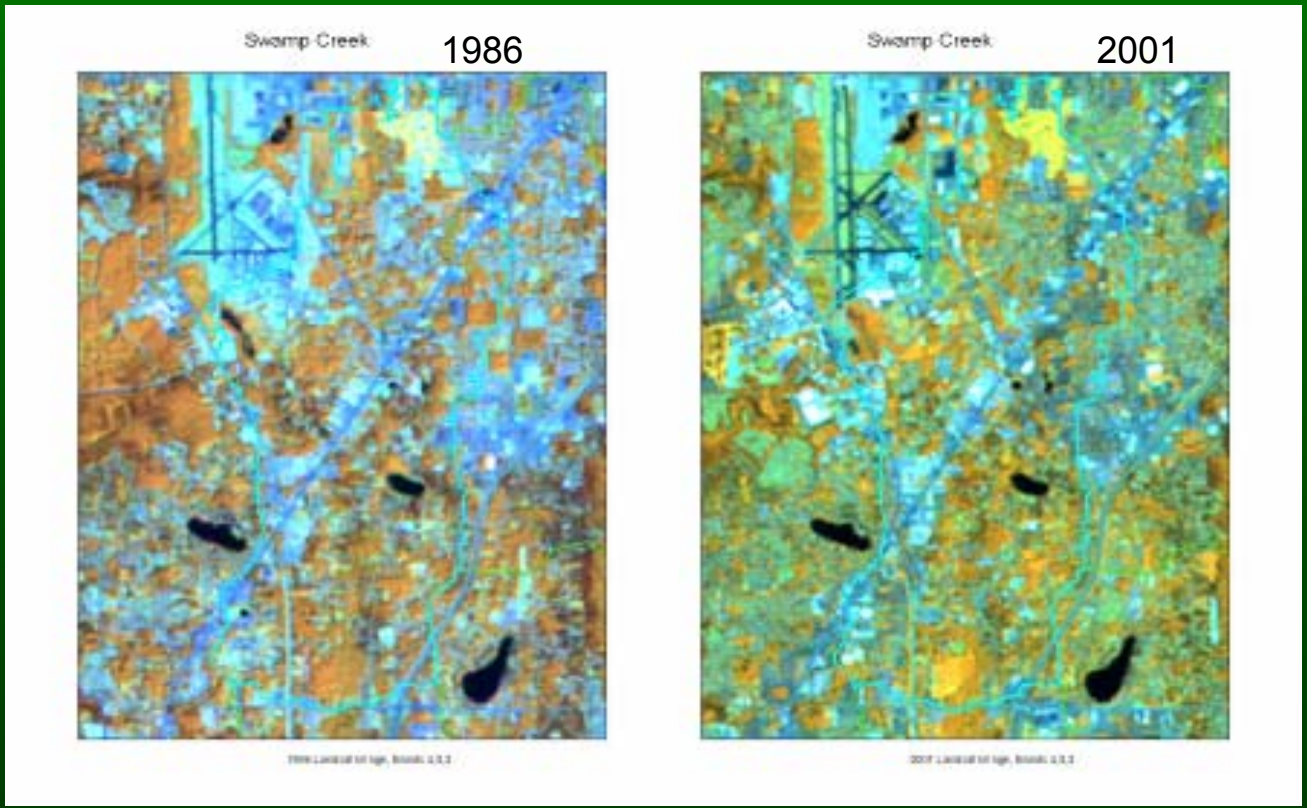
Focus on Freshwater Habitat Influences

- Annual values at each site expressed as % of total spawning fish at all sites
- Reduces effect of out-of basin influences - assumes marine conditions (except harvest) experienced by the fish from all sites are comparable
- Examining changes in the distribution of spawning coho salmon over time among the 84 index sites – not a change in absolute abundance

	High Marine Survival		Low Marine Survival	
	Abundance of Spawners	Proportion of Spawners	Abundance of Spawners	Proportion of Spawners
Site 1	5000	25%	50	25%
Site 2	10000	50%	100	50%
Site 3	5000	25%	50	25%

Land Use Change Analysis

- Delineate watershed above each index reach
- Determine loss of forest cover from LandSat imagery
- Interpret land use change associated with loss of forest cover from county zoning
- Assign index watershed to a “Land Use Change Class”
- Evaluated accuracy of class assignment protocol using aerial photographs

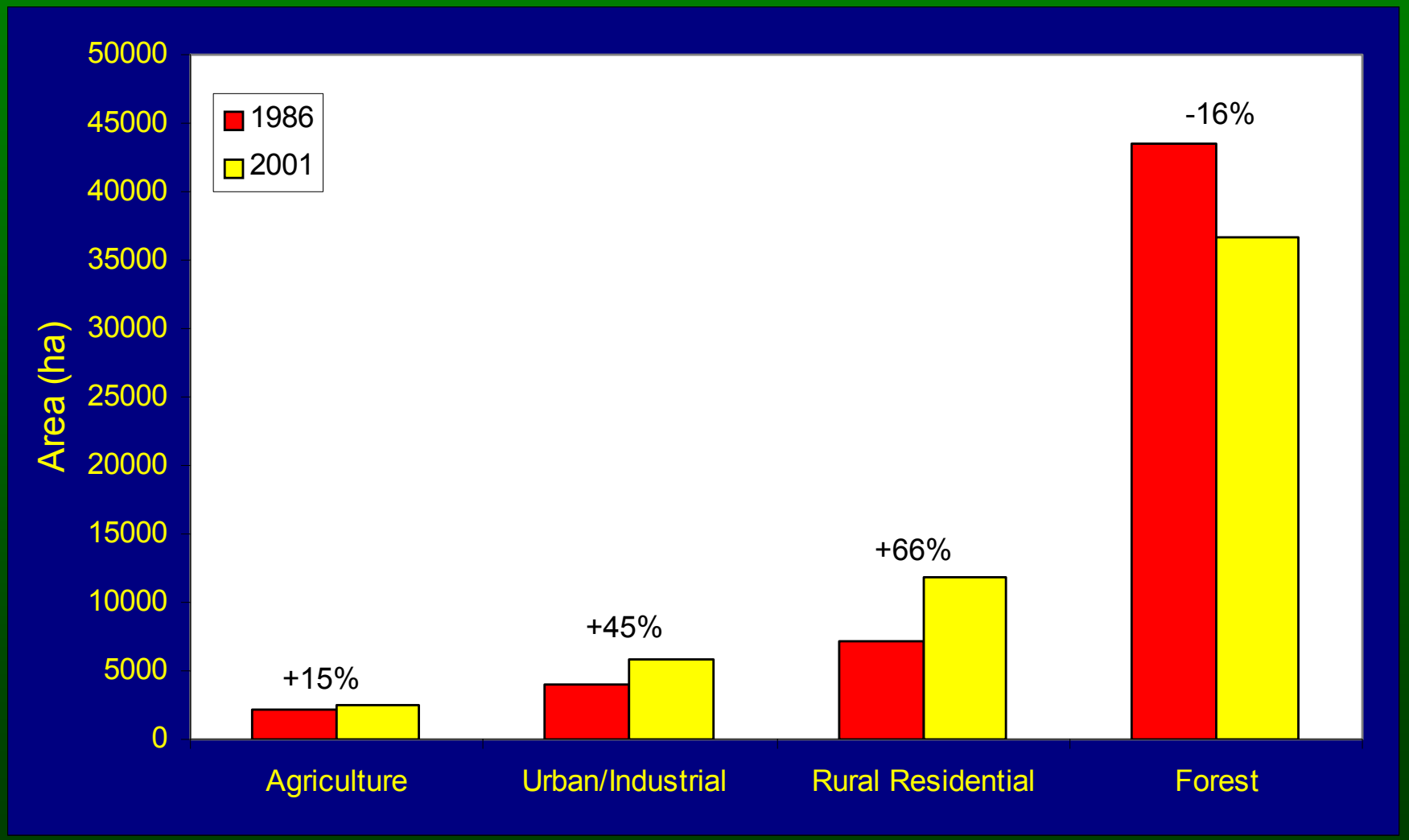


Land Use Change Classes

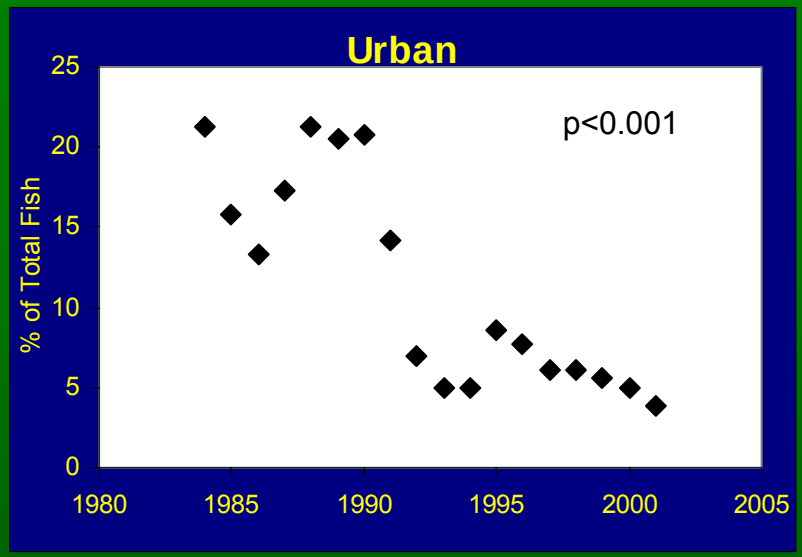
- Five classes based on the type of land use change that occurred between 1984 and 2001: Urban, Agriculture, Rural Residential, Forest (logging), Forest (no logging)
- A land use change ≥ 1% of the index watershed area was set as the minimum for inclusion in a class
- This approach lead to some watersheds being assigned to more than 1 class

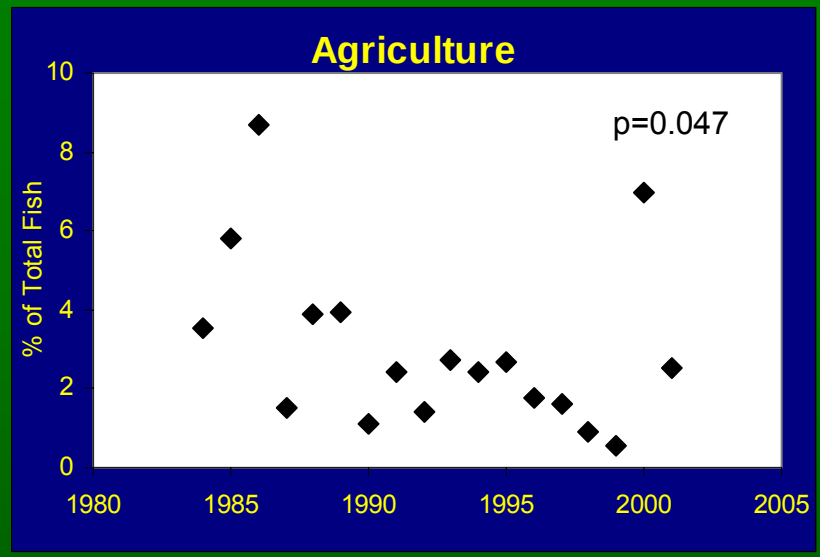
Urban = 12 sites; Agriculture = 5 sites; Rural Residential = 45 sites; Forest (logging) = 22; Forest (no logging) = 12

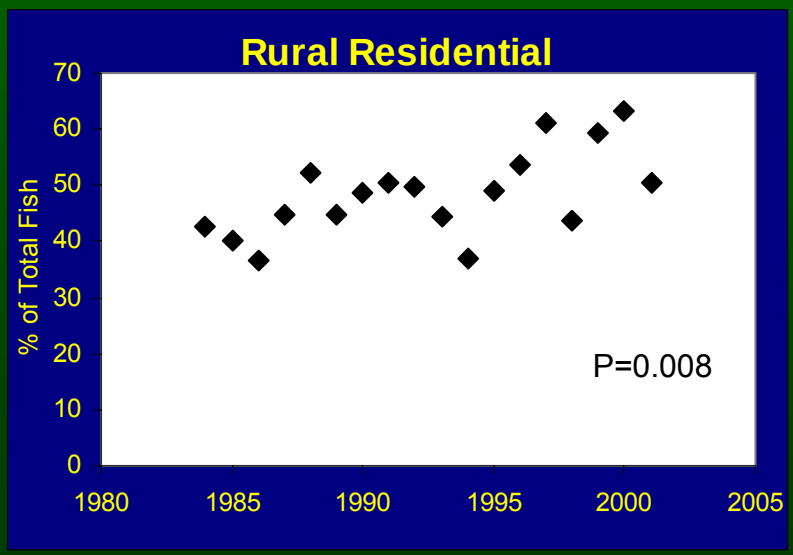
Changes in Land Use – Index Watersheds

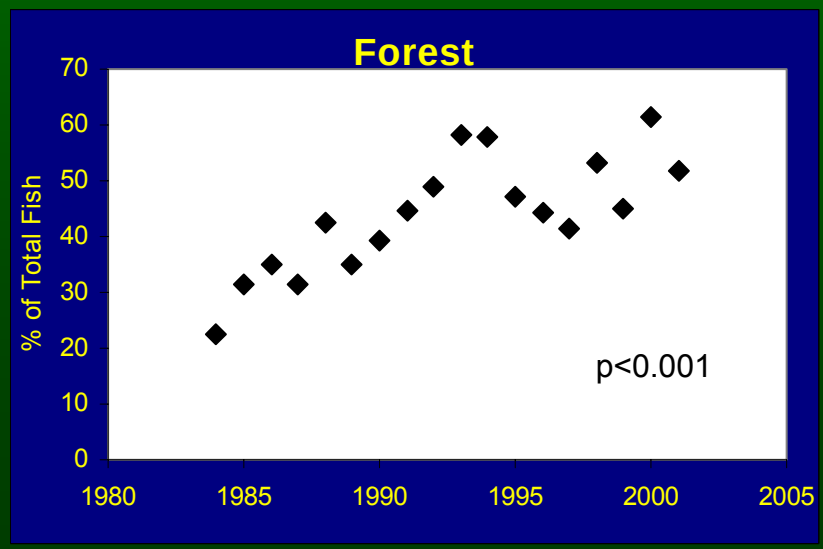


Change in Fish Distribution

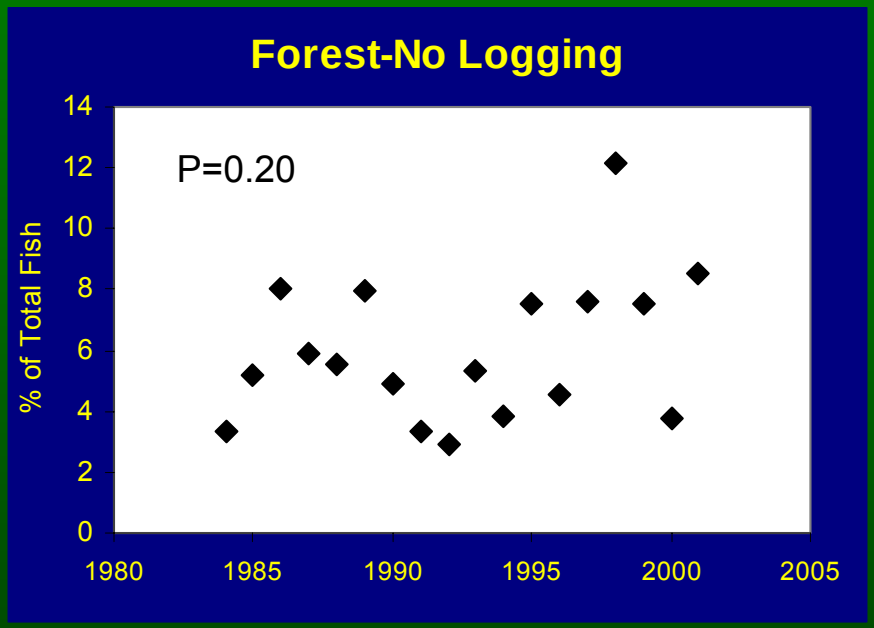


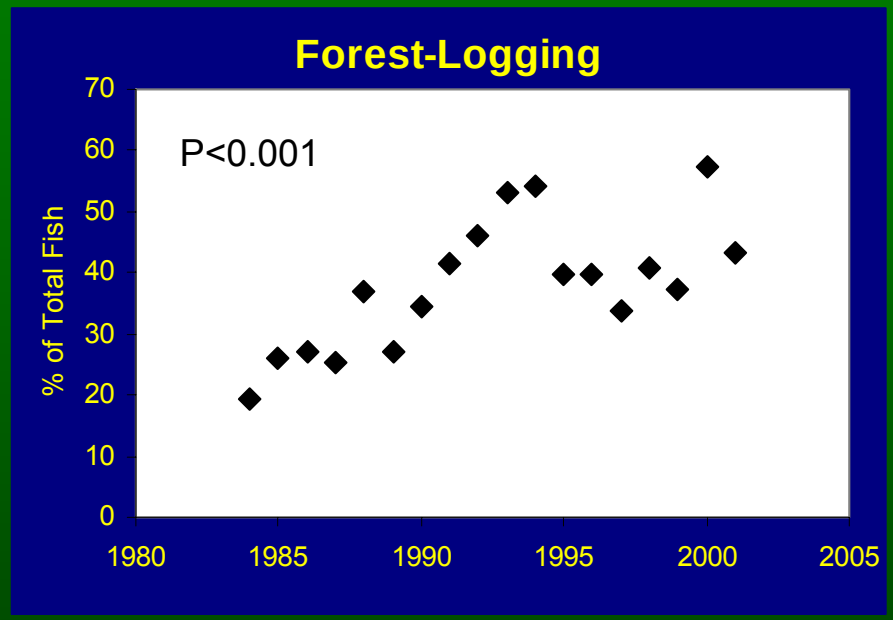




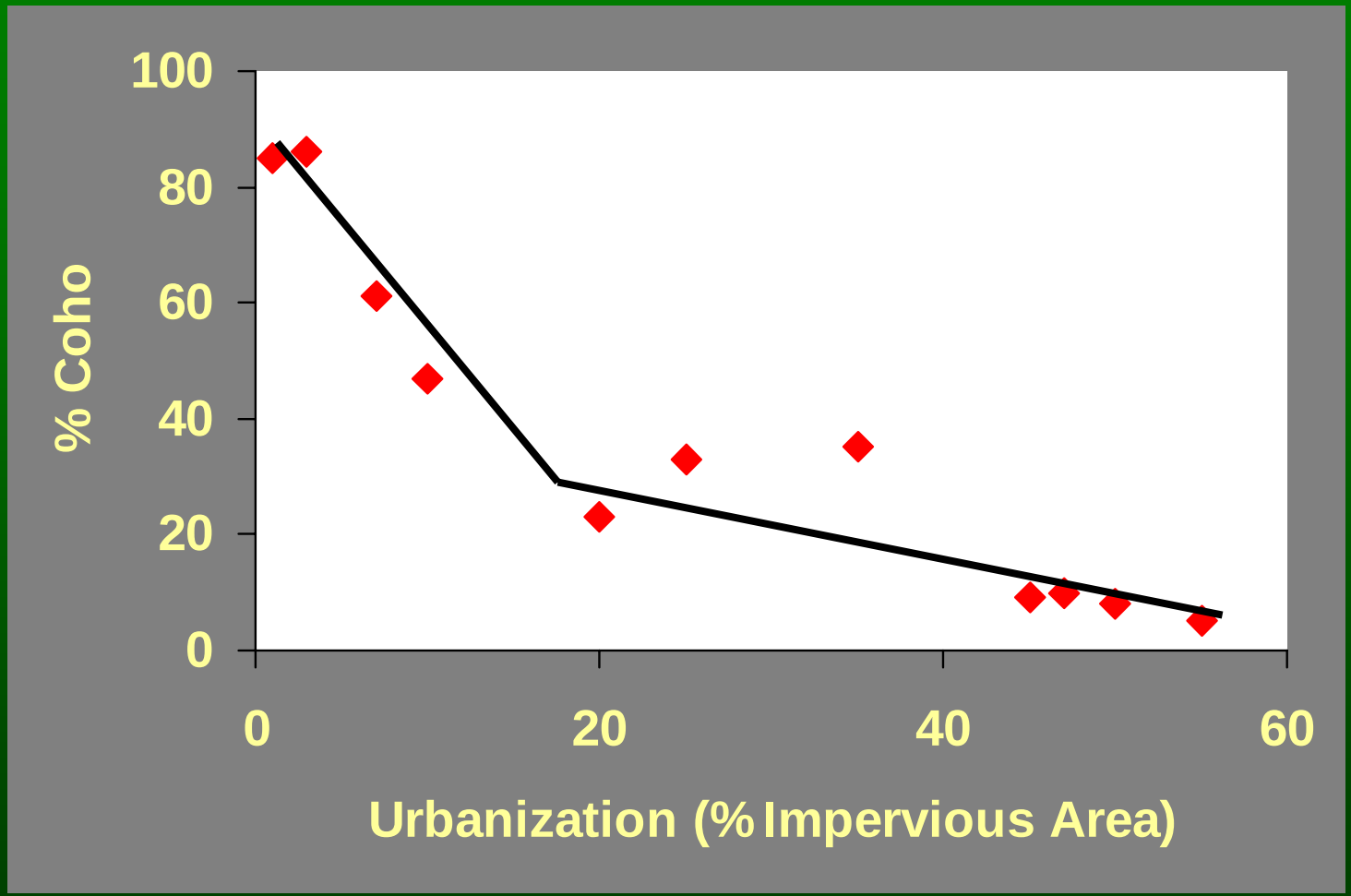


Logging vs. No Logging





Urbanization and Fish Community Composition



Luchetti and Fuerstenberg 1993

Physical Effects

- Simplification of channel form
- Alteration of riparian vegetation
- Removal of large wood
- Reduction and alteration in litter input
- Substrate alteration
- Disconnection from floodplain

Altered Hydrology

- Higher peak flows
- Lower, more persistent low flow
- Years between 5-year flood events
  - Forested watershed - 5 years
  - Urbanized watershed - 1.1 years
- Impacts on streams
  - Increase bed scour
  - Reduced bank stability
  - Higher sediment input
  - Flushing of organic matter
  - Reduction in system productivity

Chemical Effects

- Industrial discharge
- Pesticides
- Road runoff
- Overabundant nutrients
- Oxygen depletion

Biological Effects

- Reduced diversity and productivity of benthic communities
- Impacts on fish populations
  - Direct mortality
  - Altered prey base
  - Reduced growth
  - Depressed immune system
  - Loss of homing ability
  - Inability to detect predators

Pre-Spawn Mortality

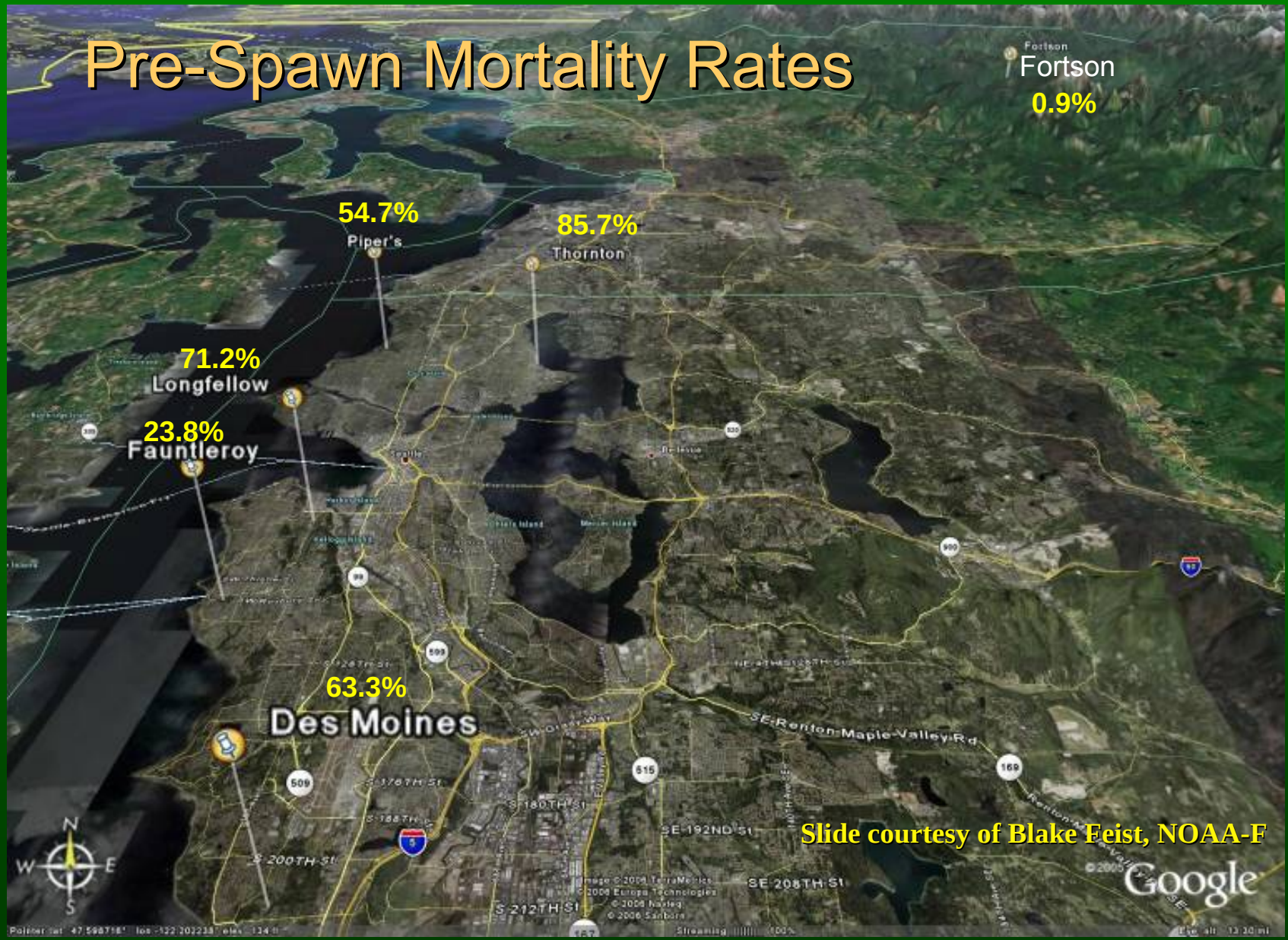
- Observed in coho in urban streams
- Mortality rates ranging from ~25-90%
- No evidence of disease or pathology, and dying fish appear to be in good physical condition
- Correlation with major roads/highways
- Copper from brake linings a possible contributing factor?

NOAA

NWFSC NORTHWEST FISHERIES SCIENCE CENTER

U.S. FISH & WILDLIFE SERVICE

Seattle Public Utilities

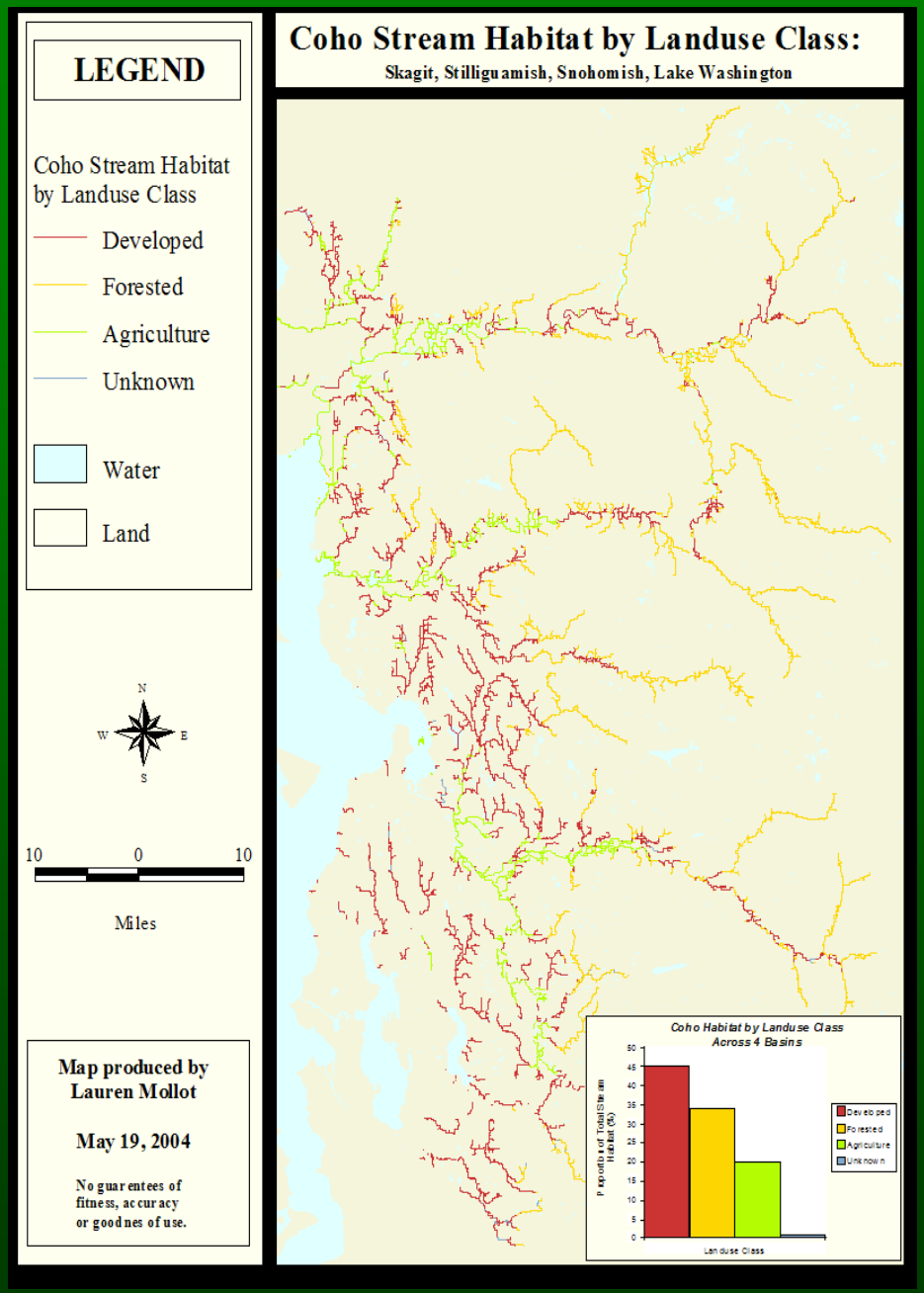

Pre-Spawn Mortality Rates
Fortson
0.9%
54.7%
Piper's
85.7%
Thornton
71.2%
Longfellow
23.8%
Fauntleroy
63.3%
Des Moines
SE Renton-Maple Valley Rd
S 200TH St
S 212TH St
SE 192ND St
SE 208TH St
Slide courtesy of Blake Feist, NOAA-F
Google

Future Status of Anadromus Fish Habitat

Skagit, Stillaguamish, Snohomish and Lake Washington Watersheds

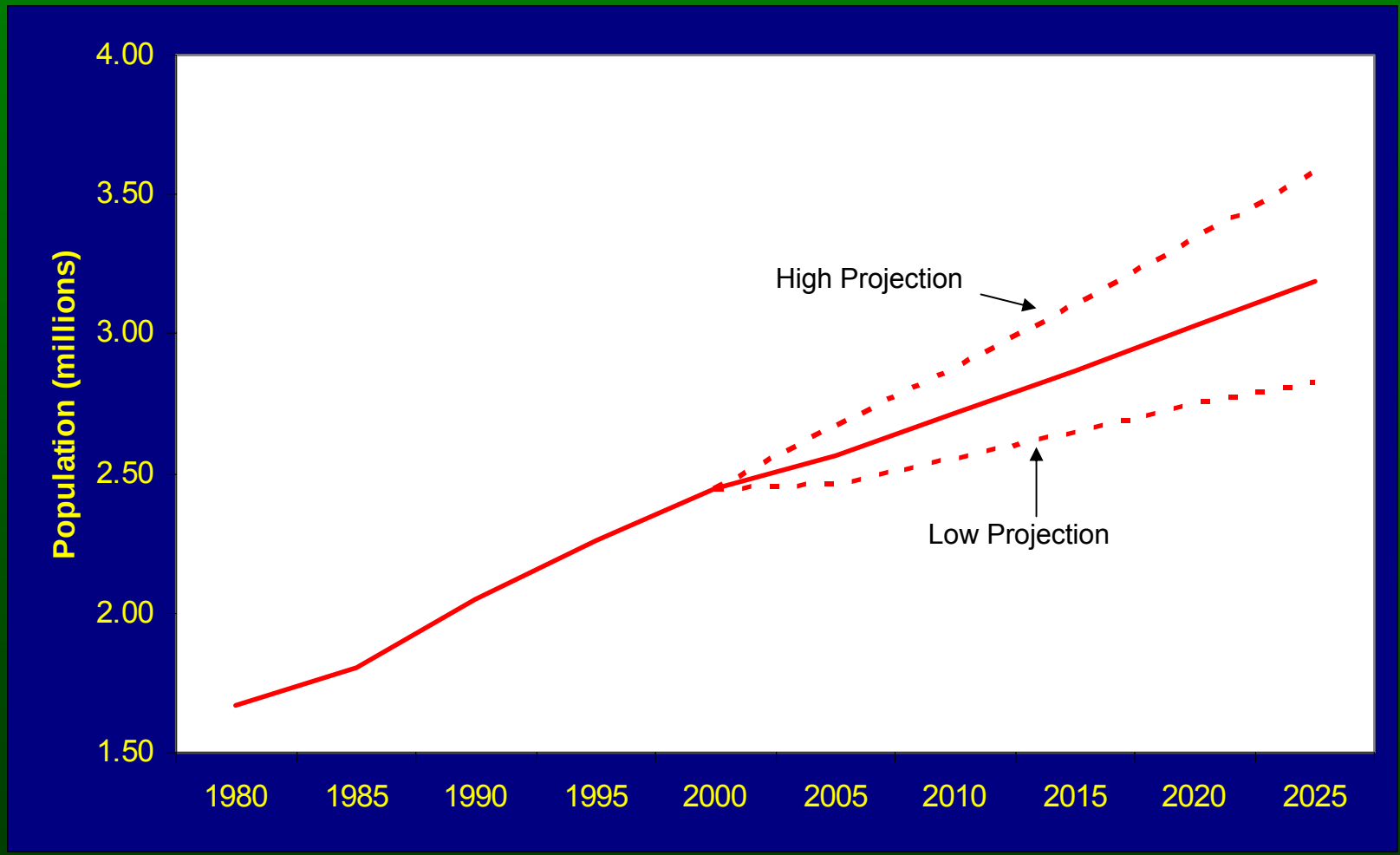
Total Area = 21,840 km^2
- Forest = 70%
- Urban, RR and Ag = 30%

Area Available to Salmon
- Forest = 35%
- Urban, RR and Ag = 65%



Historic and Projected Population Trends

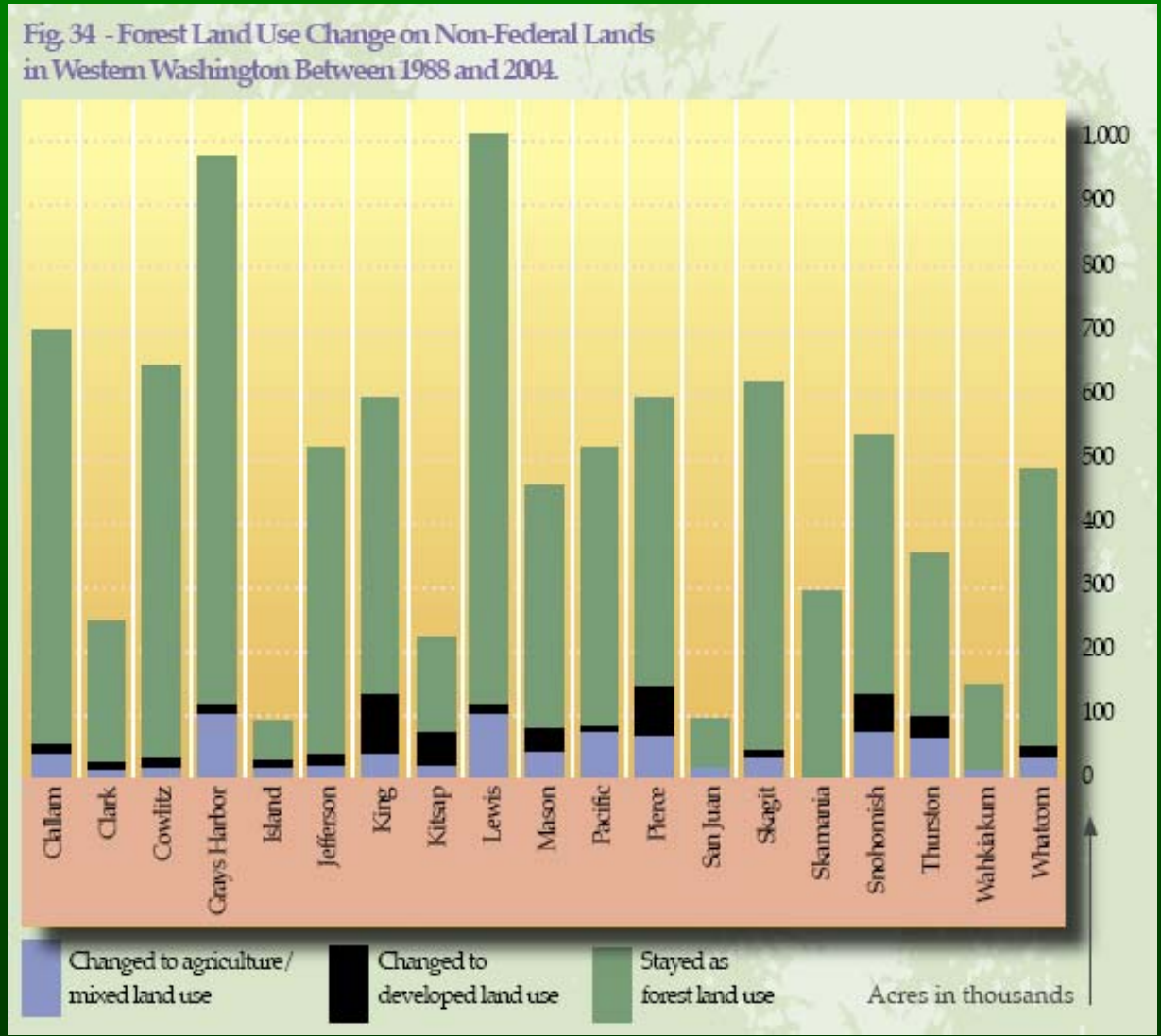
King, Snohomish and Skagit Co., WA



Forest Conversion in Washington

1988-2004

Rate of Private Forest Land Conversion in WA = 0.37%/yr
25,000 acres/yr
(Bradley et al. 2007)



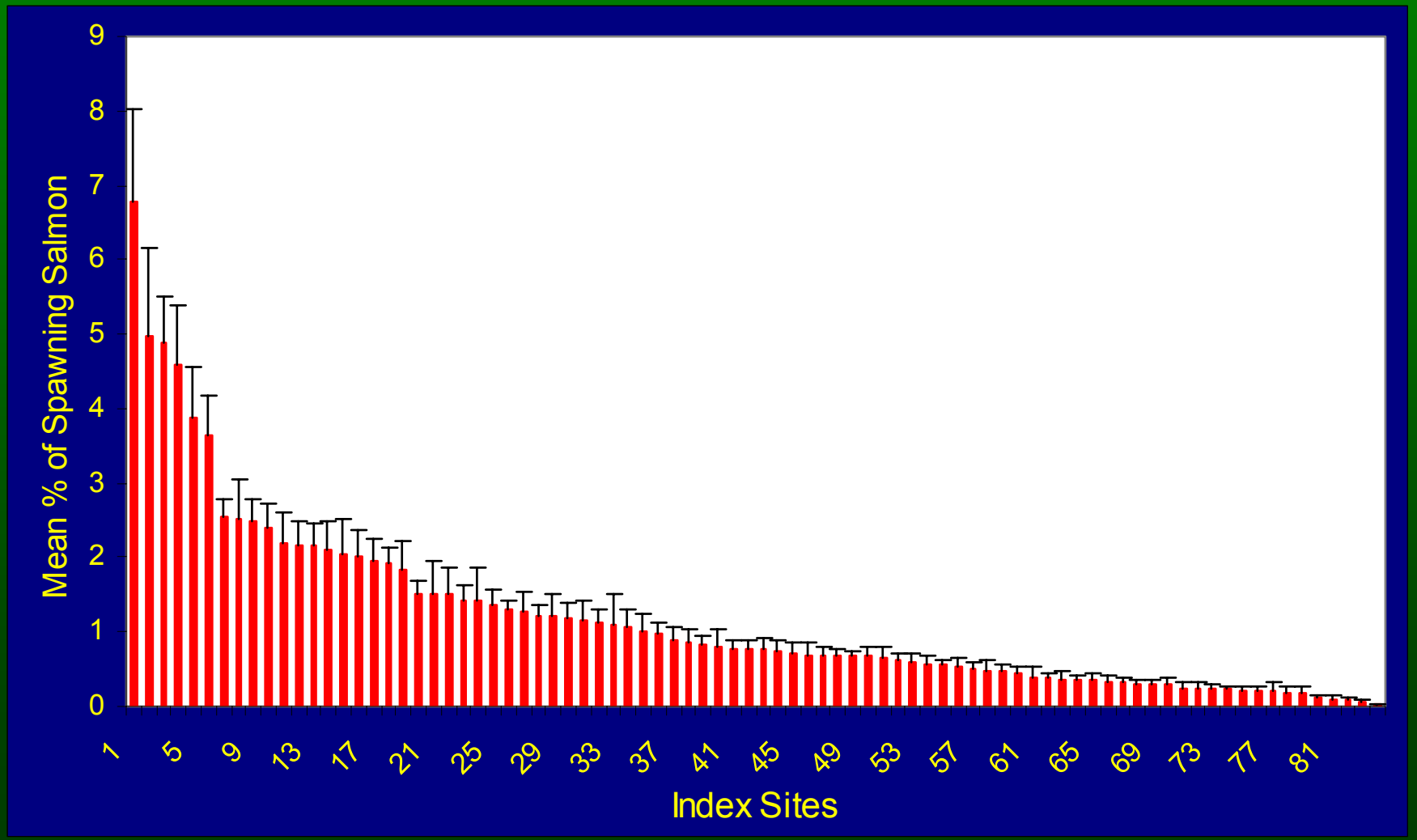
DNR 2007

Can Salmon Persist in Urbanizing Regions?

- These data indicate a significant negative trend in coho salmon spawning in urbanizing watersheds
- Despite regulatory changes and restoration efforts in urban areas, no evidence that urban watersheds can sustain large salmon populations
- Is it possible with technological advances and more stringent environmental control of future development? – not known
- Likely that Coho salmon spawning and production will continue to shift to areas of lower-intensity land use (forest, rural residential)– areas accessible to salmon with these land uses will become increasingly rare

Average Distribution of Spawner Abundance

1984-2001



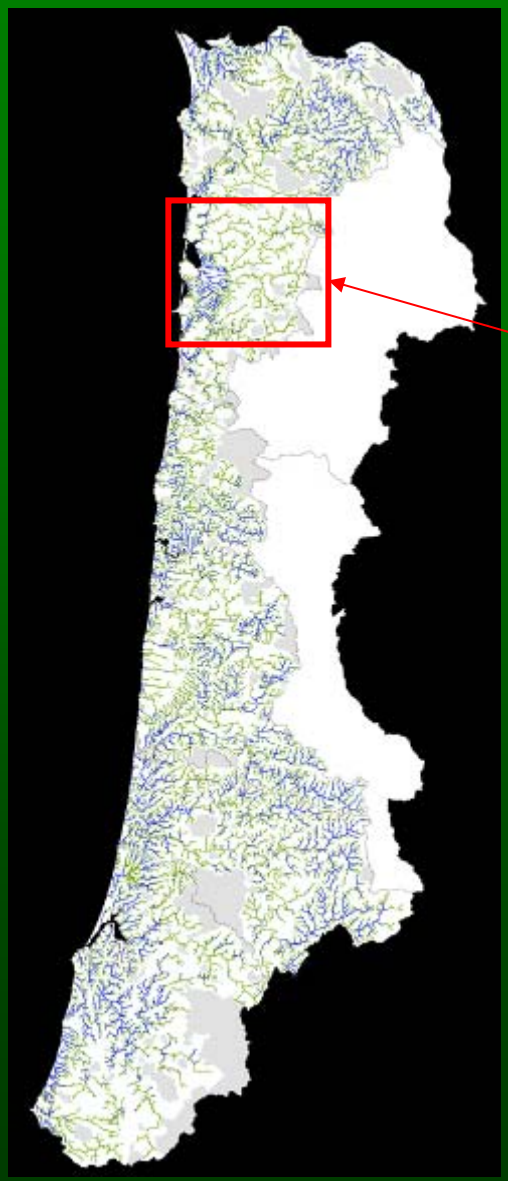
Retaining Salmon in Areas with Rapid Growth

- Areas most productive for coho salmon are low elevation, low relief
- These locations most susceptible to conversion to more intense land use
- Retention of naturally spawning populations of anadromous fishes may require:
  - Improved understanding of the regional distribution of biological potential; identification of highly productive locations
  - Protecting these sites from detrimental human impacts
  - Steering future intensive development towards areas with low potential to support salmon and/or already compromised by current land use
  - Incorporation of salmon recovery plans into traditional land use planning
  - Development of zoning or regulatory approaches more targeted and flexible than those currently used
  - Increasing the value of forest land relative to other land uses

Identifying High-Productivity Sites

Intrinsic Potential- Coho

CLAMS Area



Tillamook and Nestucca

N High
N Low-Med

Figure from K. Burnett, USFS

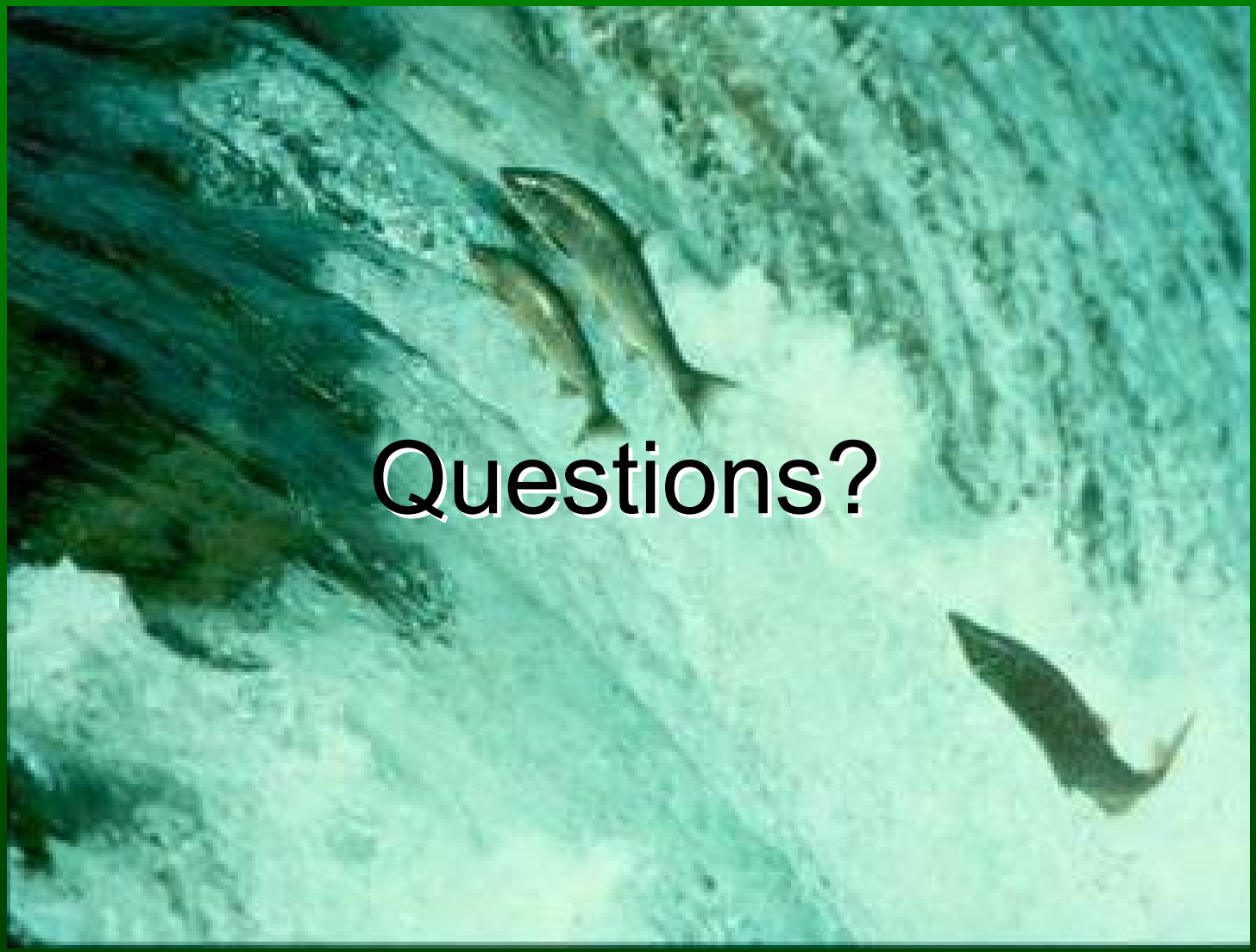
Increasing Forest Land Value

Non-Traditional Products

- Possible revenue streams
  - Sale of development rites, conservation easements
  - Recreational access
  - Carbon sequestration
  - Production of C-neutral fuels from forest biomass for Mitigation for loss of fish/wildlife habitat during development
  - Compensation for improved water quantity and/or quality
- Financial return on these “products” unclear; sufficient reduce rate of forest land conversion?
- Altered management required for some of these options; may have associated environmental impacts

Shift in Priorities for Restoration Funding

- Recognize that urban stream restoration is unlikely to benefit salmon and shift resources to locations with less intense land use and some assurance of future protection
- Focus restoration on locations with the physical conditions capable of supporting high productivity


Questions?