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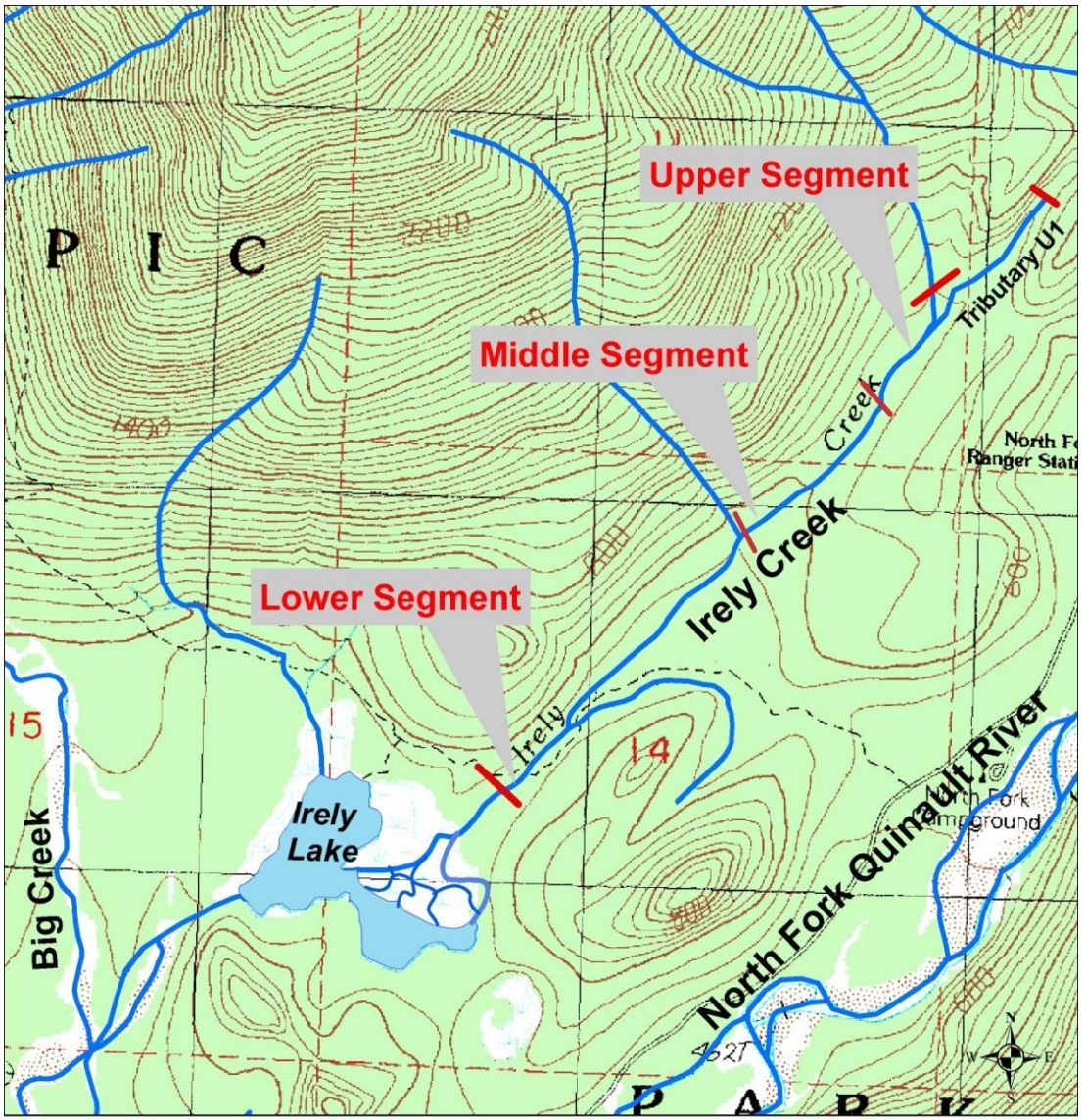
Long-term population response of Coastal Cutthroat Trout (CCT) to environmental fluctuations in a temperate-rainforest stream: hydrology, temperature, and invasive weeds & other biotic factors

Presentation assistance:
Jill Silver (10KYI), Pat Crain (NPS), & Alex Foster (USFS)

Study Area

(collaborated w/ NPS)



Irely Creek
Olympic National Park
Washington

October, 2005

0 600 1,200 2,400 Feet

Can We Predict Future Trout-Run Size?

*** We began intense microhabitat-HSI work on an abundant CCT run** (in only 1 of 2 lake tribs)

SU/FA trout angling in Irely Lake (catch & release)

But run decline after 2002 lake dry-out (SU/FA)

- In assoc. w/ (since 2002) expanding *beaver dams* (which provide pool refuges for fishes)
- And *reed canarygrass (RCG)* influx D/S & in lake (bare mud in FA 2002)

Follow-up surveys of trout redds during 2015-18 (for model testing)

Continued redd surveys into future

- CCT recovery from *RCG removal* via lake-level &/or WQ'l benefits?
- *Out-of-kind mitigation* (for hydrology) = field experiment

Can We Predict Future Trout-Run Size?

*** 2001-18 "natural experiment" of CCT ecohydrology**

Several physical & biotic variables assessed (cumulative impacts?)

- Lake level, streamflow, & Forks (WA) precipitation
- Snowpack in the Olympic Mountains

Forage-fish sampling via stream > lake netting & snorkeling (especially during summer/fall)

- Few fish spp. in these headwaters (but *other trout* in lake)

Can We Predict Future Trout-Run Size?

* **Stream walks** to estimate salmonid escapements
  - Coho carcass/adult counts (esp. late winter)
    # Mainstem & 5 larger tributaries
    # Some yrs. w/ earlier &/or later counts (for full-escapement estimation)
  - Trout-redd counts (adults rarely on nests) (*Vadas et al. 2016*)
    # Upper, middle, & lower mainstems (the latter w/ long-term *beaver dams & RCG*) & tributary U1

Cutthroat Trout Rearing

- **Adfluvial (lake-rearing) stock**
  - Dominant fish in Irely Lk.
    - Mostly adults
  - Subdominant in Irely Cr.
    - *YOY* dominant here
      * ~2 mo. incubation
    - *Juveniles* common to age 2+
    - *Adults* uncommon
      * Resident fish the only spawners after SU/FA drought years (natural selection)?
      * Less commonly seen above larger (0.9-1.5 m) waterfalls that temporarily form in upper segment *(unlike coho)*
  - Run size uncorrelated w/ that for sea-run coho there (in the same year)

Cutthroat Trout Escapement

- **Spawning in mainstem & 1 headwater tributary (U1)**
  - Field methodology *(Vadas et al. 2016)*
    - 2001-2 (full counts before lake dry-outs, but spatial extrapolation upstream)
    - 2003-12 (usu. only 2 peak-season counts in later years, w/ spatiotemporal extrapolation [via flood-caused turbidity D/S &/or incomplete walks U/S])
    - Estimated adult coho:cutthroat ratio during 2001-12 was 1.3-60.5 (median 8.9, above expected, healthy ratio of 4:1 for PNW streams)
  - Main-channel > side-channel habitats
    - Late peak; early > late April (mid-late March to mid-early May spawning)
      - Vs. WDFW's SASI report for periodicity *(Vadas et al. 2008)*
      - 0.5-1.5 mo. when T_w = 4-10^{O}C (peak ~6^{O}C) for 2010-18 (coldwater-oriented)

Summer/Fall Ecohydrologic Dynamics

(esp. 1-y time lag suggests adult kills; *Vadas et al. 2016*)

- **<u>Full lake dry-out</u> (creek intermittent)**
  - # 2002-3 (two years in a row) & 2009
    - * Impacted 2003-4 & 2010 CCT runs
    - * Then run recoveries (2005 & 2011-12)
- **<u>Semi-dry</u> (lake reduced, creek low)**
  - # 2005-6 (two years in a row w/ 2006 dry-out)
    - * Impacted 2006-7 cutthroat runs, then trout-run recovery (2008)
  - # 2010 (two years in a row w/ 2009 dry-out)

    - * *Coho recovered* in 2010
  - # 2000 (three years in a row w/ *full dry-out* in 1998)
    - * Likely impacted 2001 trout run
    - * But ~K-level run of 2002 (nearest to *carrying capacity*)

Summer/Fall Ecohydrologic Dynamics

- Cutthroat-run escapement (adult-run size)

Estimated as 2*redd count (1:1 sex ratio & all adults spawned)

Decreased by 3.5-8 times after lake dry-outs

Increased by only 2-3 times after wetness returned

Hence, the general run drop during 2001-18

* But notable recovery for 2011-15 (w/ increasingly good lake levels)

- Statistical analyses (on transformed data)

Spearman & Pearson *correlation (also factor) analyses*

Stepwise, linear, & curvilinear *regression analyses*

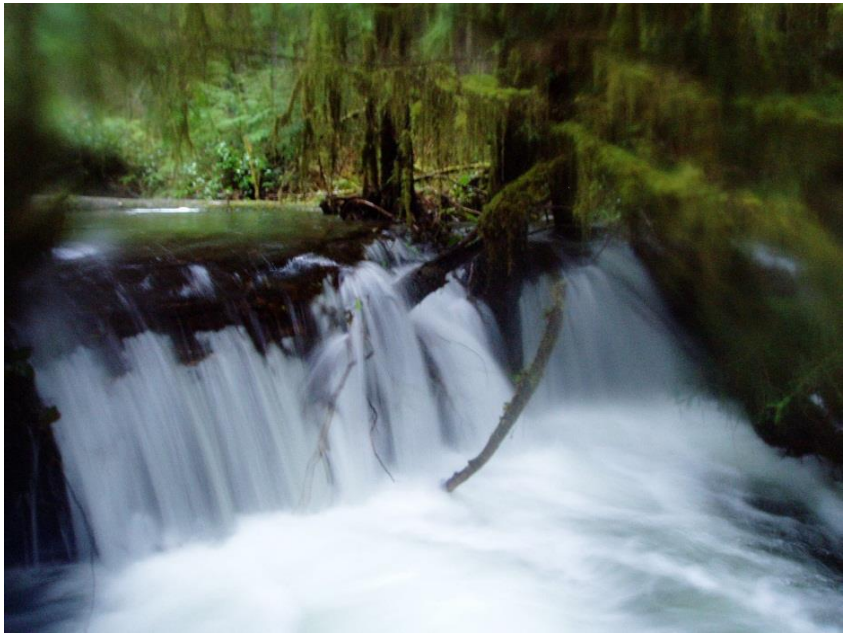
Trout-Environmental Relationships

- **Unimportant variables**

  # Present-year physical (flow/thermal) & biotic (coho-abundance) conditions (*minor sea-run effect*, at best)

  # Some last-year physical conditions (*spawning habitat* rarely limiting & *flood protection* seen in headwaters)

    * Hydraulic-drop "barriers" in the upper mainstem *(braiding)*
    * Flood-scour impacts (during & after trout spawning)



Trout-Environmental Relationships

- Important variables (final mult.-regress'n model)

Hydrology (short time lag = landlocking)

* Cumulative (drought-related) impacts
  - Across years (even though *preceding year* was strong effect)
  - *Best lake model*; dry = +1, semi-dry = +0.5, & wet = -1 points

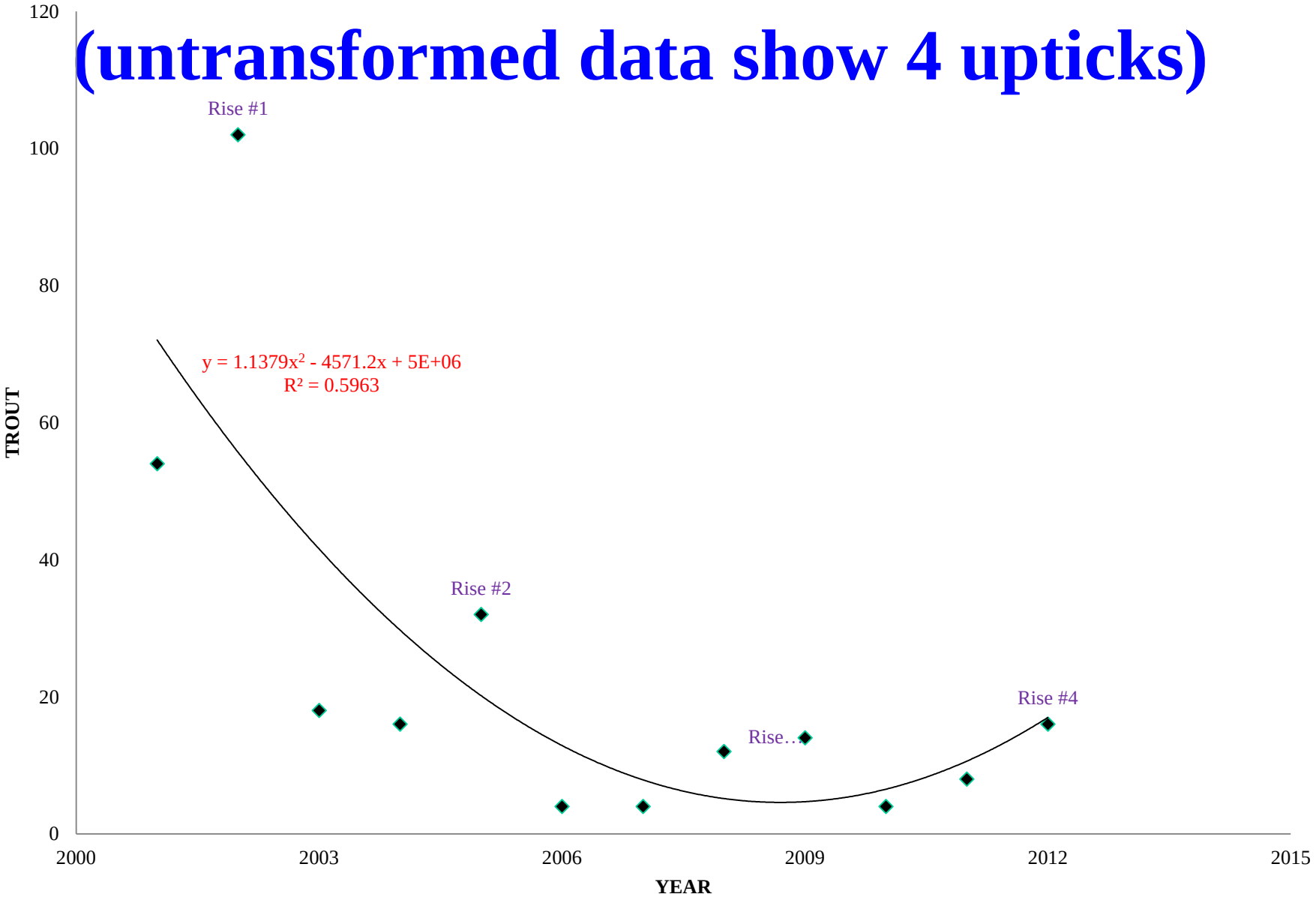
Cumulative thermal (peak CCT-spawning) variable

* Last > present year index (coldwater benefits)

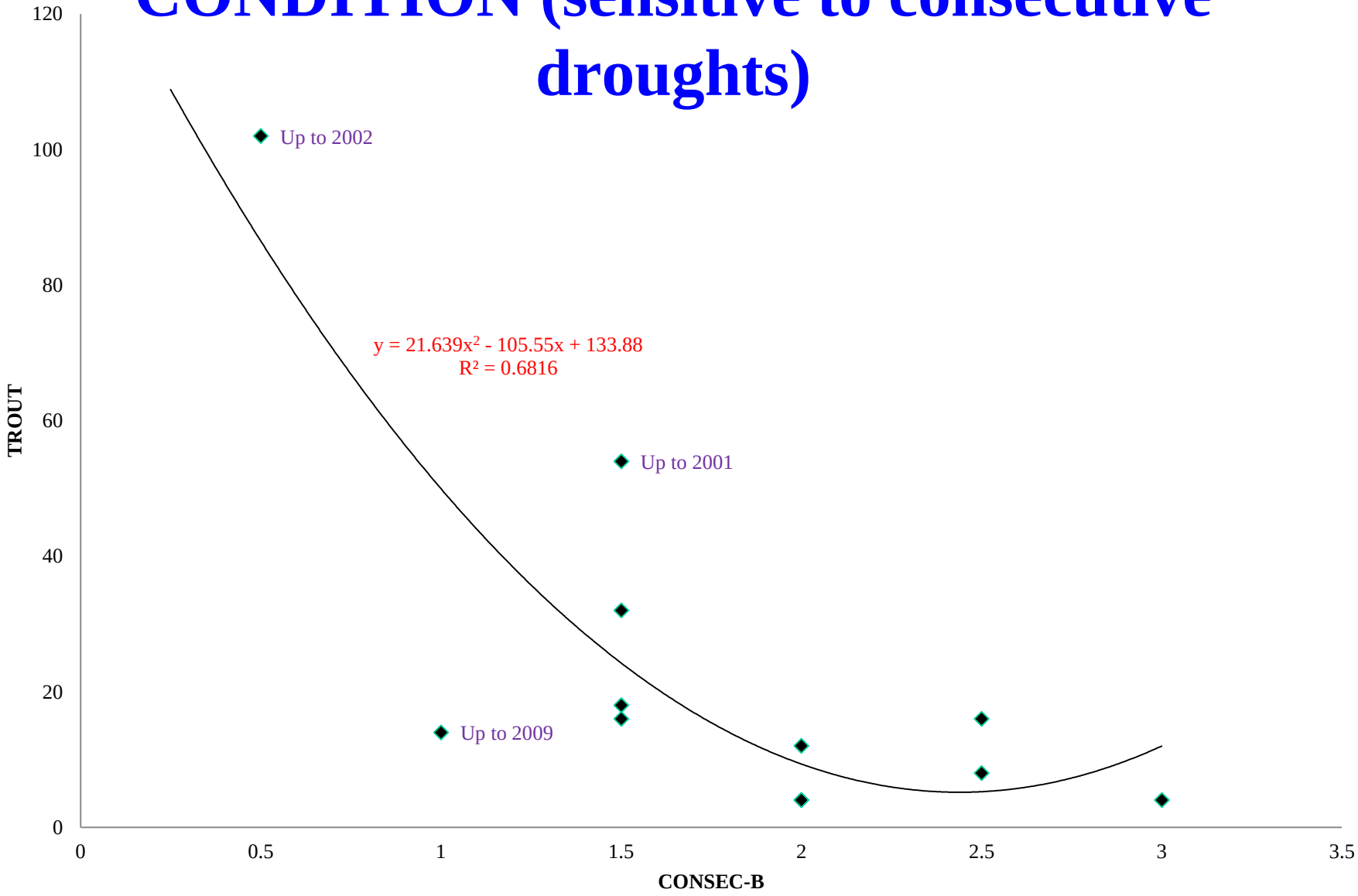
Last-year biotic (density-related) variables (mostly beneficial; *minor curvilinearity*)

* Cutthroat escapement (forecast'g)
  - Weaker (likely *Beverton-Holt*) density dependence
* Food abundance (coho salmon)
  - *Late-winter* carcass/adult abundance *(flood effect?)*

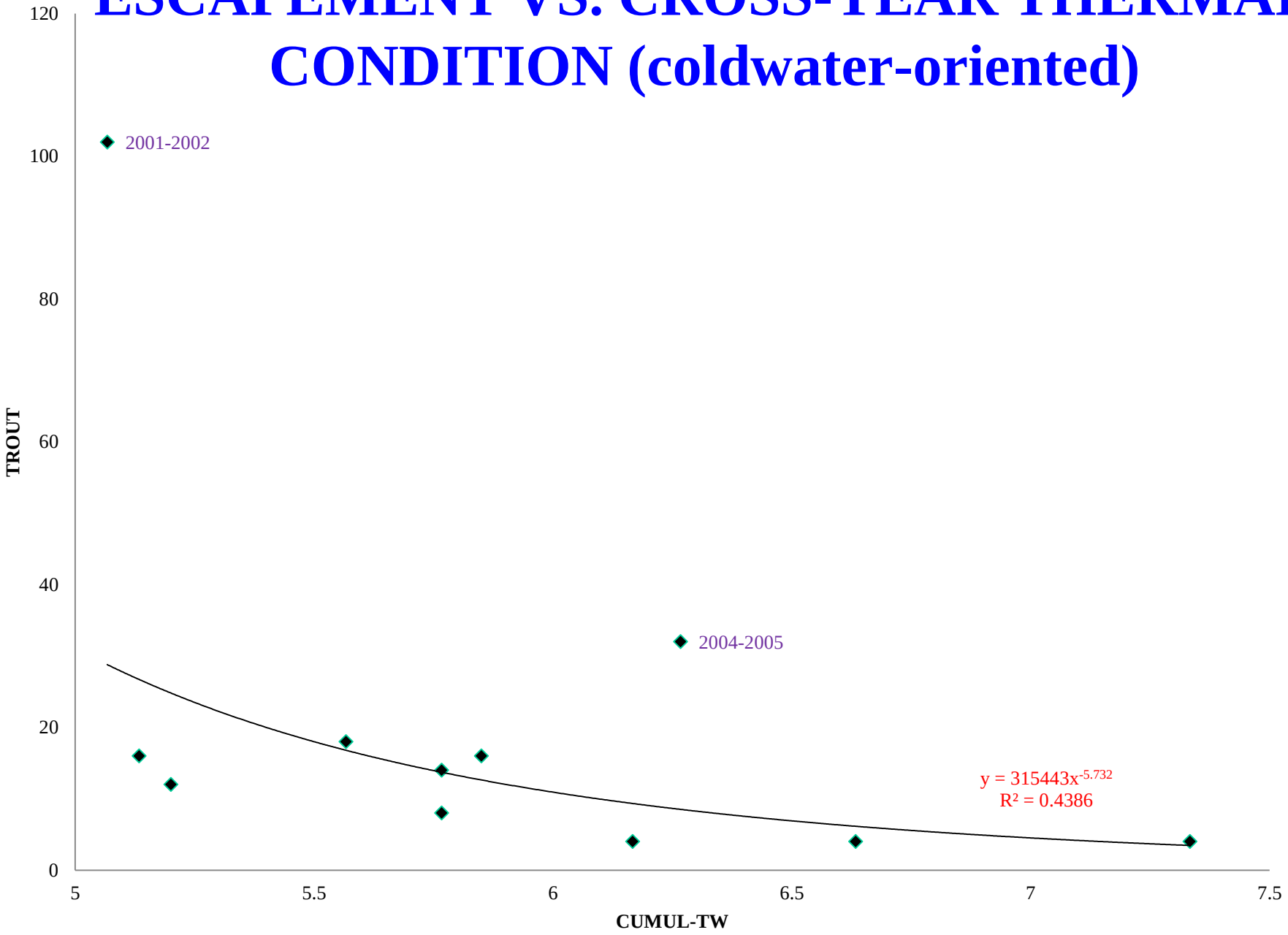
ESCAPEMENT ACROSS YEARS (untransformed data show 4 upticks)



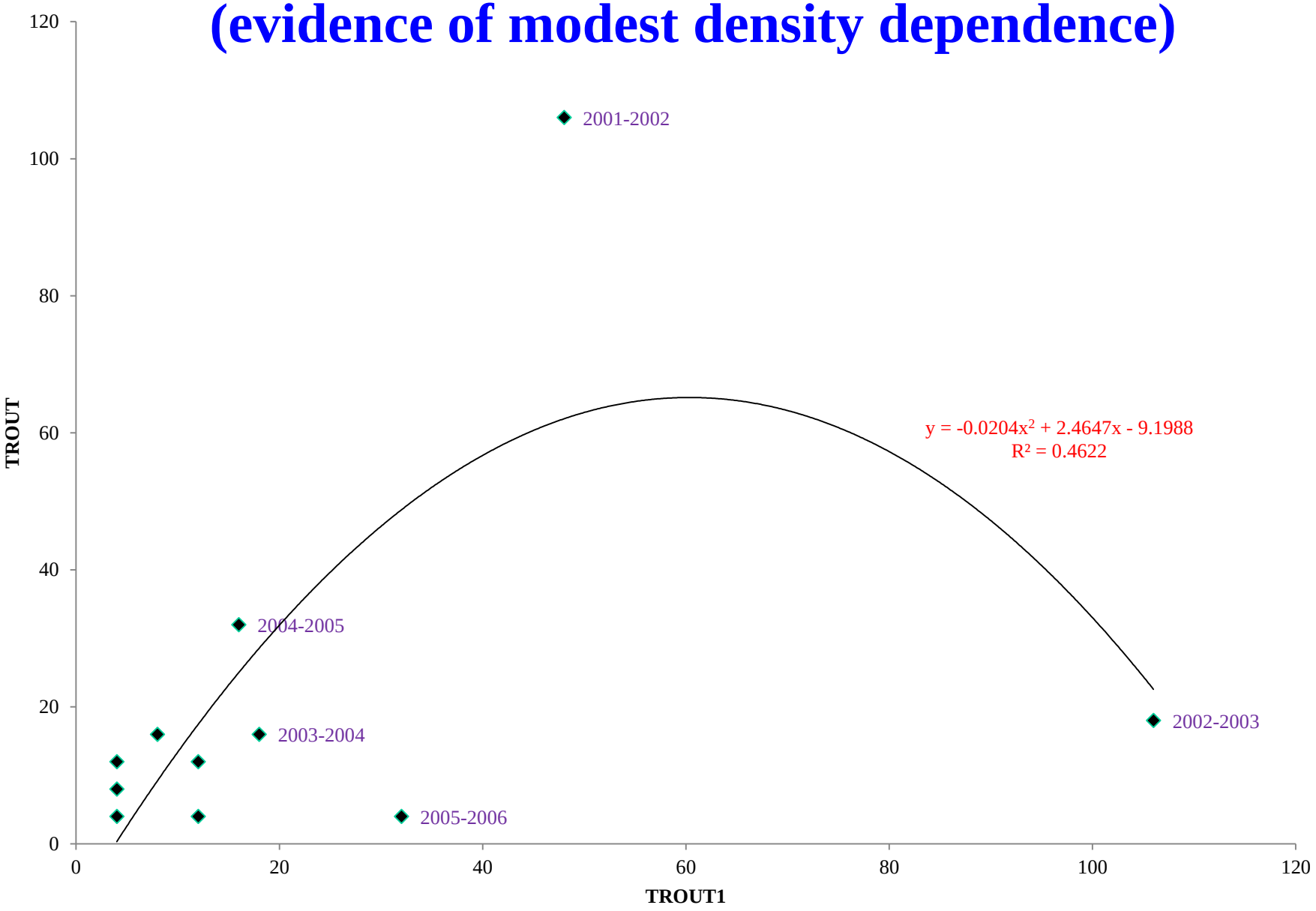
ESCAPEMENT VS. CROSS-YEAR LAKE CONDITION (sensitive to consecutive droughts)



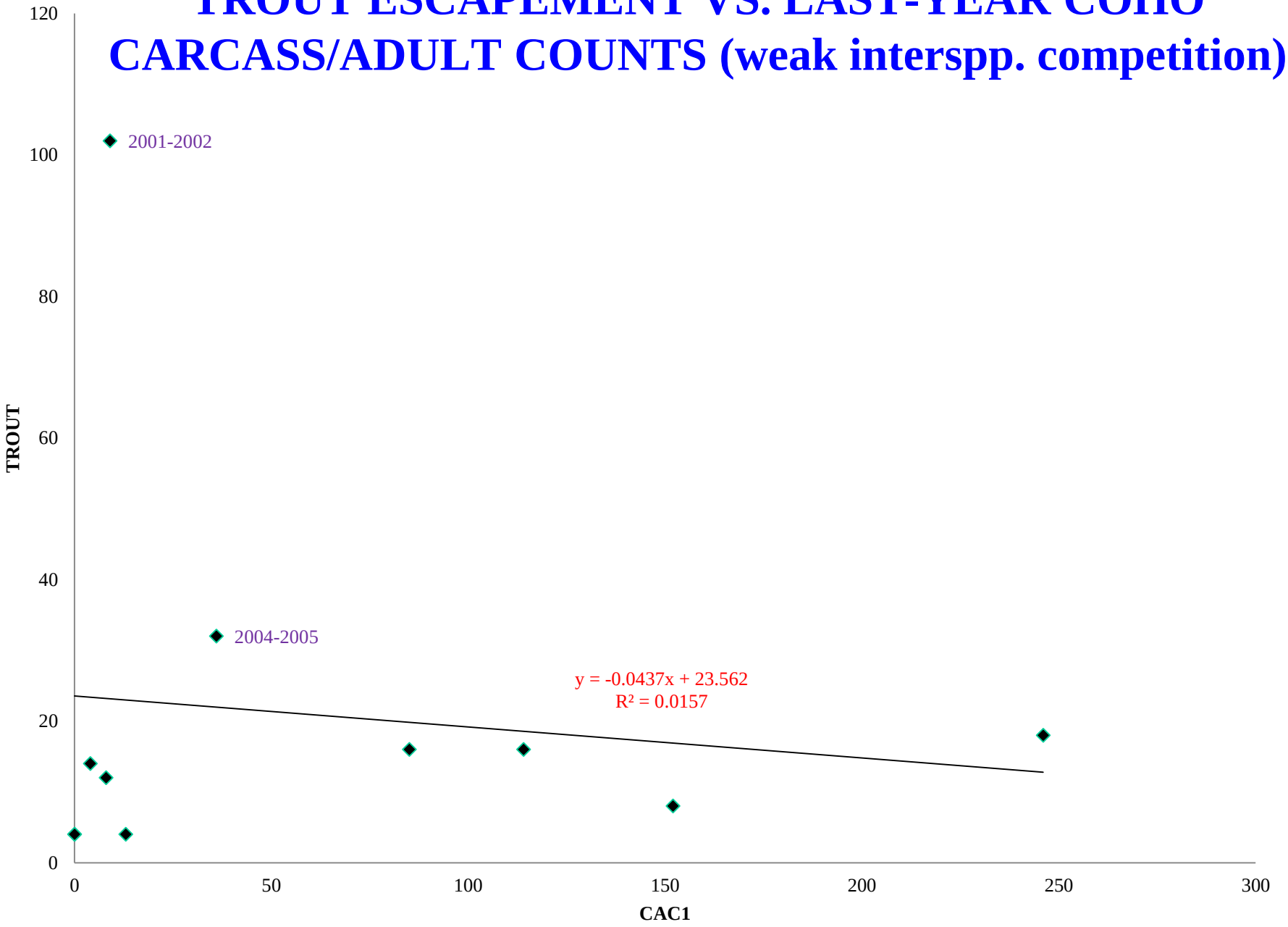
ESCAPEMENT VS. CROSS-YEAR THERMAL CONDITION (coldwater-oriented)



PRESENT- VS. LAST-YEAR TROUT ESCAPEMENT
(evidence of modest density dependence)



TROUT ESCAPEMENT VS. LAST-YEAR COHO CARCASS/ADULT COUNTS (weak interspp. competition)



Effects of Warm-Weather Dry-Outs: 1998-2000, 2002-3, 2005-6, & 2009-10

- Irely Lk. often dries out down to middle Big Cr.

Full dry-out has recurred over the last few decades

* Based on remote-sensing info during 1984-2012 *(Vadas et al. 2016)*

* Worse dry-outs since interdecadal-climate shift of 1999 *(oddly)*

Dying sculpins, crayfishes, & dragonfly nymphs there

Hence, cutthroat is a climate-sensitive species *(cold-adapted)*

* Despite its *groundwater preferences* (i.e., relatively low spawning flows)

Effects of Warm-Weather Dry-Outs: 1998-2000, 2002-3, 2005-6, & 2009-10

- <u>Possible large-fish refuge</u> in flatter, deeper reach near Irely Lk. (pool-dominated)

Immature coho & cutthroat of various sizes in mainstem

<u>Perennially flowing</u> in most mainstem reaches (w/ some *residual pools* D/S)

Loss of <u>trout-fishing action</u> of 1990s

- Middle Big Cr. (intermittent fish passage)

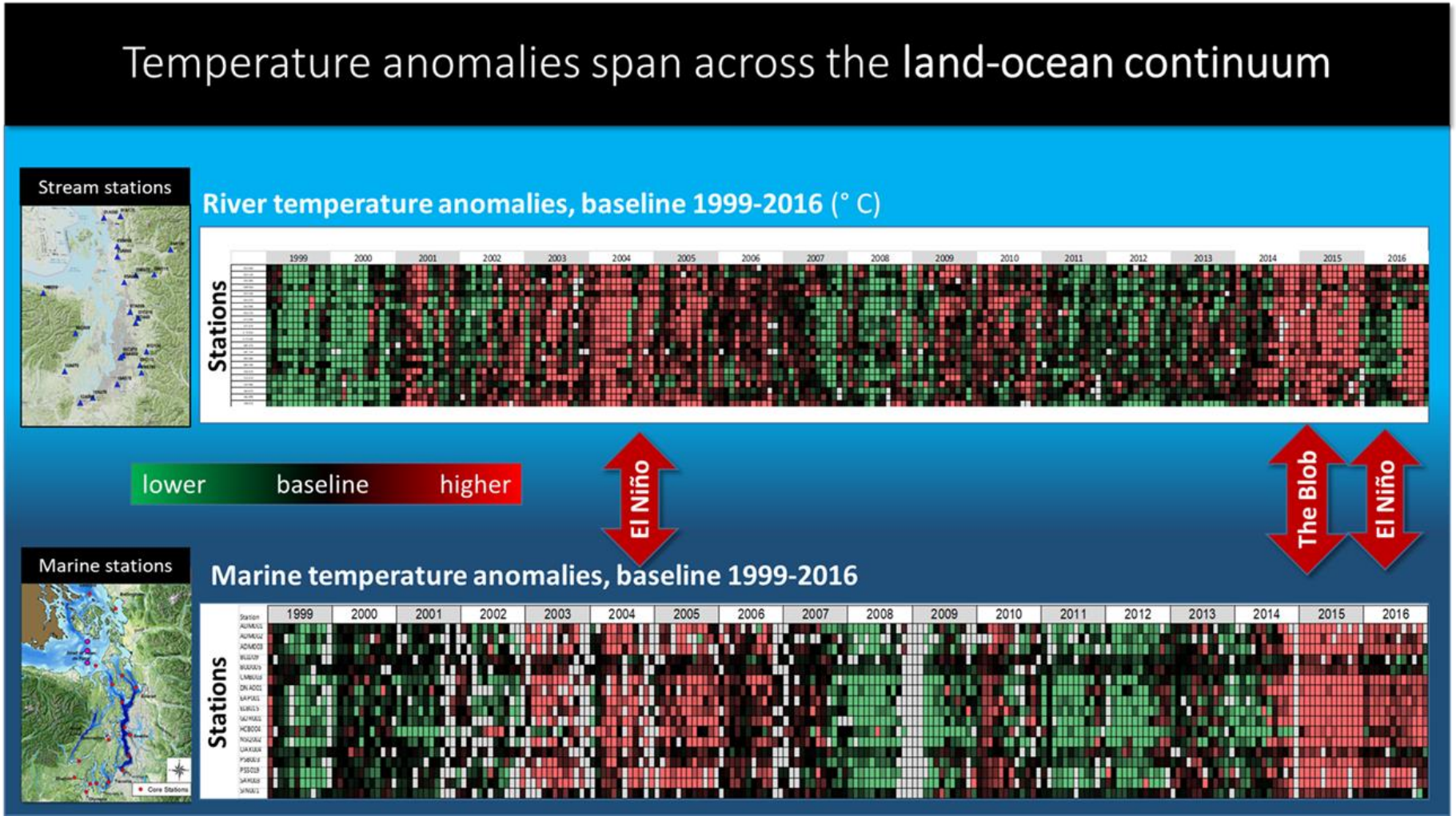
<u>Hyporheic flow</u> during non-winter months (*flood scour*)
* Unlikely refuge *(until now)*

But 2-3 *salmon spp.* spawn here

<u>Well-forested watershed</u> likely compensates (allowing *salmonid persistence*)

Biophysical Conditions Since 2015

(major drought via El Niño/blob impacts, as portrayed by WDOE thermal data for Puget Sound, c/o Dr. Christopher Krembs)



Irely Lake - 2015 Drought

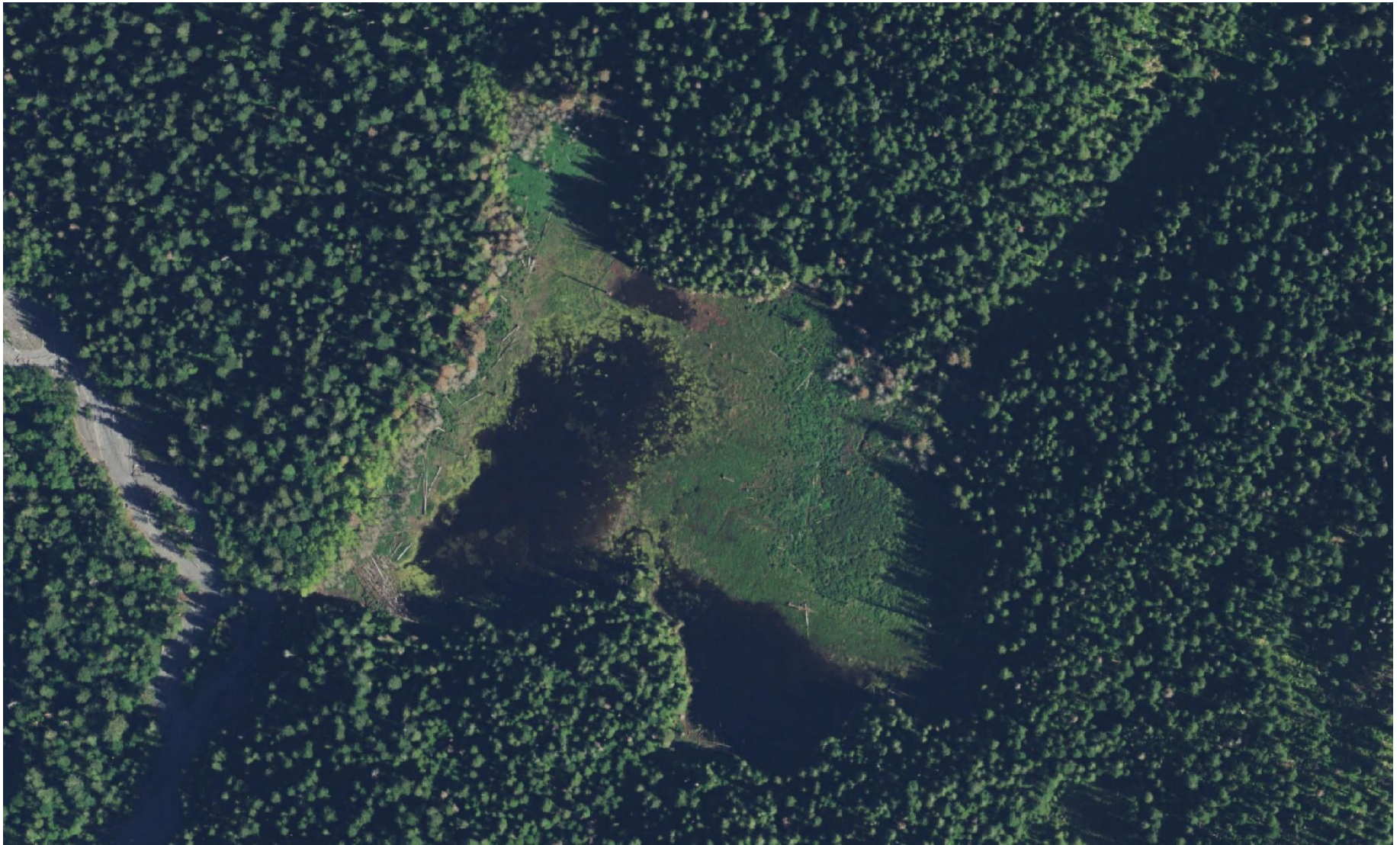
(<u>Aug. > dry</u>, showing bare & RCG [weedy] areas that reflect depth trends)

Irely Lake - 2015 After Rain

(Sep. full, showing some exposed RCG)

Irely Lake - 2017 Post-Blob

(Aug. < full, showing mid-levels of exposed RCG)



Biophysical Conditions Since Major Drought of 2015-16

- Moderate trout escapement in 2015

22 (somewhat > 16 for 2012)

* Likely better lake levels for sampling hiatus of 2013-14

- Irely Lk. dry-outs during 2015-16

Escapement dropped to 4 in 2016 *(Aug. photo w/ RCG)*

But escapement rose to 8 in 2017

- Escapement nil in 2018

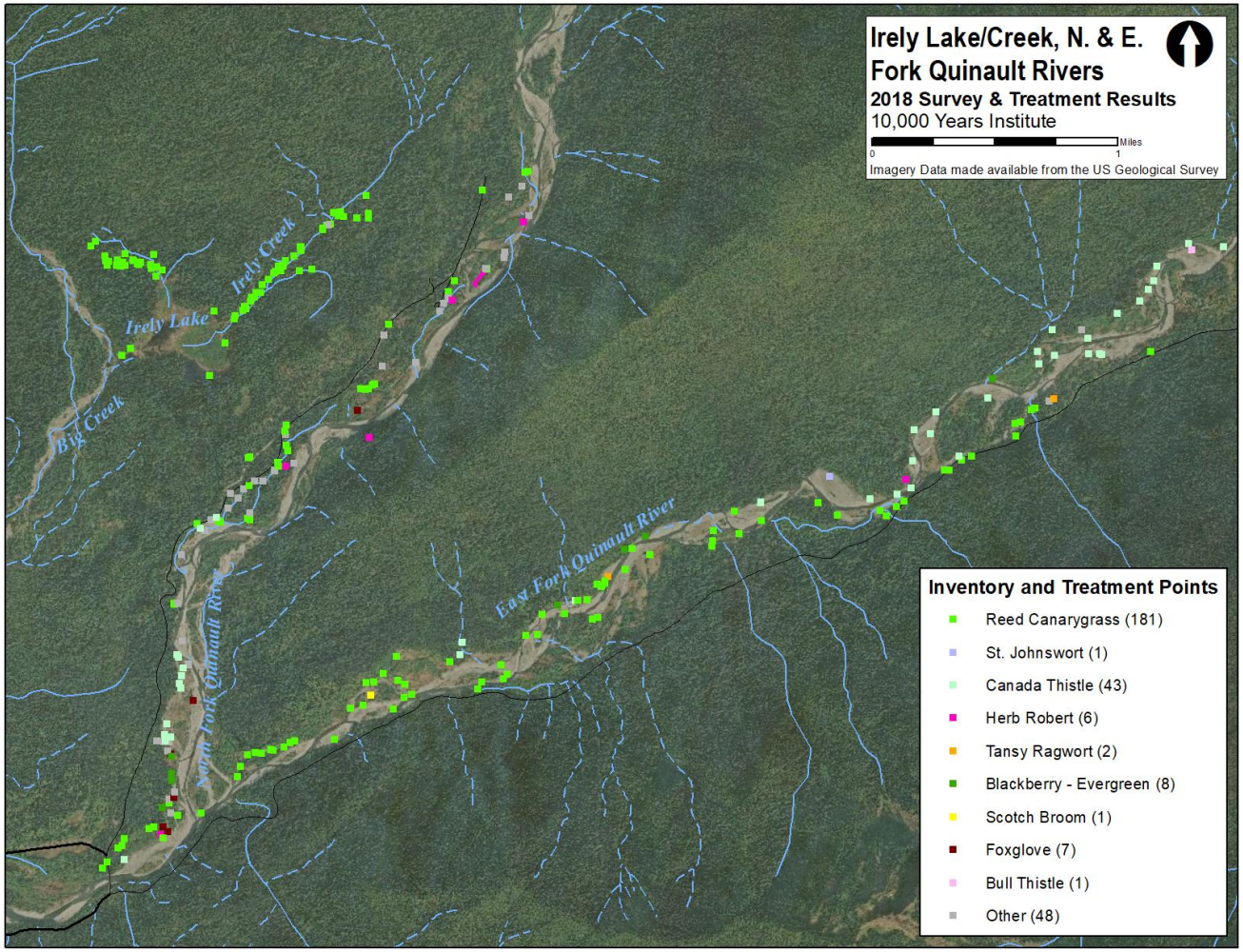
1st time to get "skunked" (0 redds)

Was incentive to start lake/crk. RCG removals during 2018 *(NPS & 10KYI)*

- Continued RCG-removal & trout-redd during 2019, etc.

Including air/crk. thermographs

SU/FA 2018 - Start of RCG-Removal Efforts

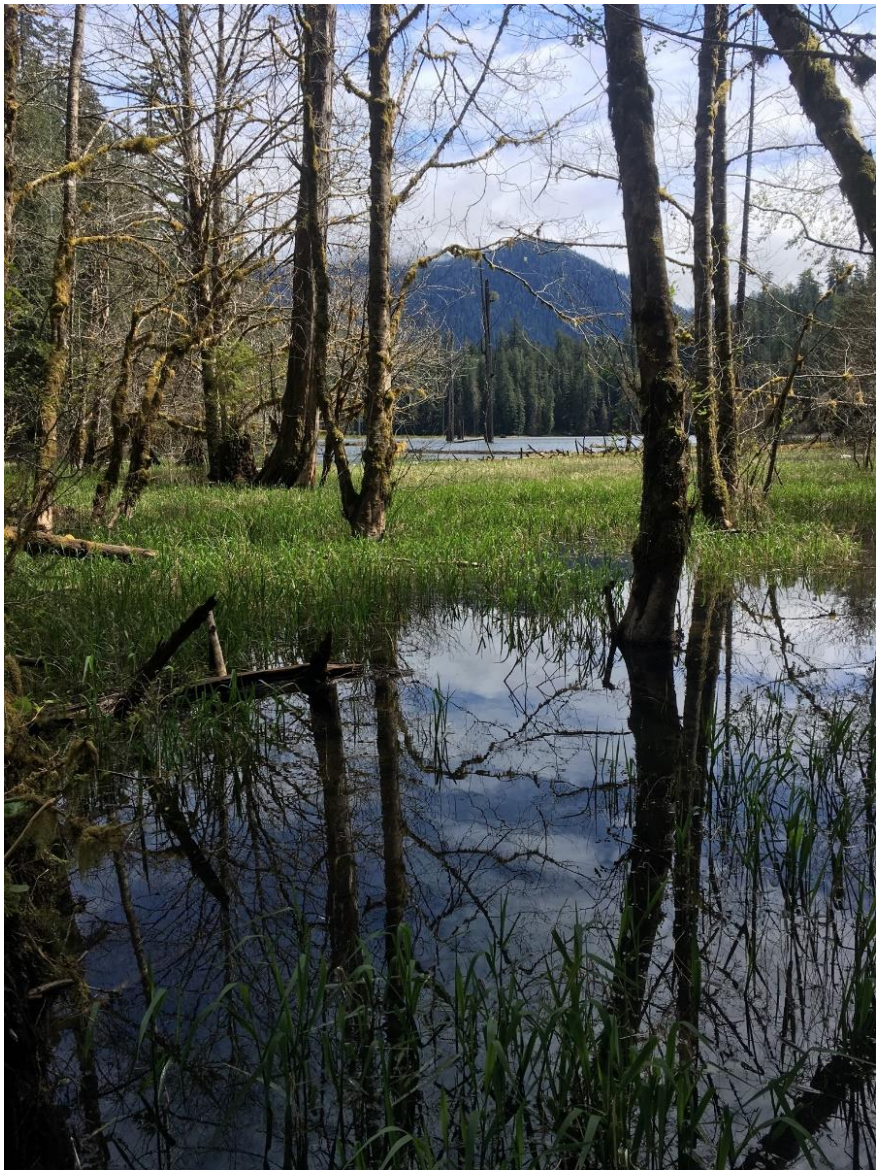


There & in N. & E. forks of the Quinault R.

Potential RCG impacts

(spring 2018 photos show a very full lake)

- Channel (lake/creek) filling & heating
- Creek flow & sediment transport
- Prey production
- Riparian succession



Conclusions

- Despite old-growth, temperate-rainforest conditions w/ high rainfall, existing water was limiting for CCT in the Irely Lake watershed (cobble/boulder sieve effect)
- Additional water use from developed, headwater streams typically impacts salmonid-population viability
  - Quantified in lower Irely Creek via *PHABSIM studies* in 2 reaches of this protected stream
- Joint riparian (e.g., RCG) & instream-flow management important for Pacific-salmonid protection in more-developed watersheds (e.g., Central/South Puget Sound)