Understanding Mercury in Rusty Blackbirds

October 2012 --- Rusty Blackbird Workshop

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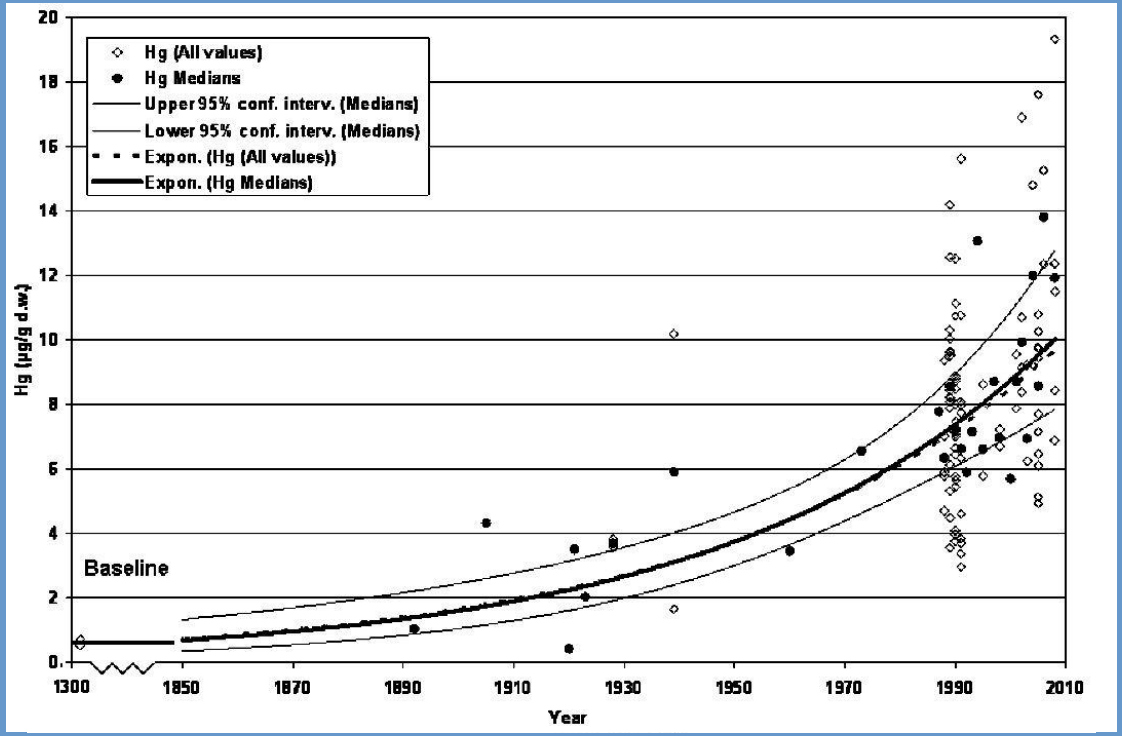
Why worry about mercury?

- Released from both natural and human sources
- People are a major contributor to global emissions
- Human contribution has increased environmental and wildlife Hg concentrations
- Mercury is converted to toxic **methyl-mercury (MeHg)** primarily by sulphur- and iron-reducing bacteria
- MeHg biomagnifies and is highly **toxic**



Fur-Hg in Polar Bears from 1300 AD to present (Dietz et al. 2011). Current fur-Hg about 6x greater than pre-industrial concentrations

Gray is natural source of mercury (Martinez-Cortizas et al. 1999)

Potential for impacts on individuals and population

Effects of Hg on birds include:

- Decreased reproductive success/productivity
- Damage to nervous, endocrine, immune systems; genotoxicant
- In general, environmental Hg exposure is not acutely lethal on adults, but may result in sub-lethal effects
- Expect greatest effects on developing young

Potential for impacts on individuals and population:
Establishing an estimated effects level for blood/feathers

- Songbirds appear to be more sensitive to Hg during embryo development than more traditionally studied waterfowl
- Expect the greatest potential for effects to occur during development – probably post-fledgling
- Decreased nesting success with increased Hg burdens (Jackson et al. 2011. Provides estimated effect levels for songbird blood, tail/body feathers, and eggs)

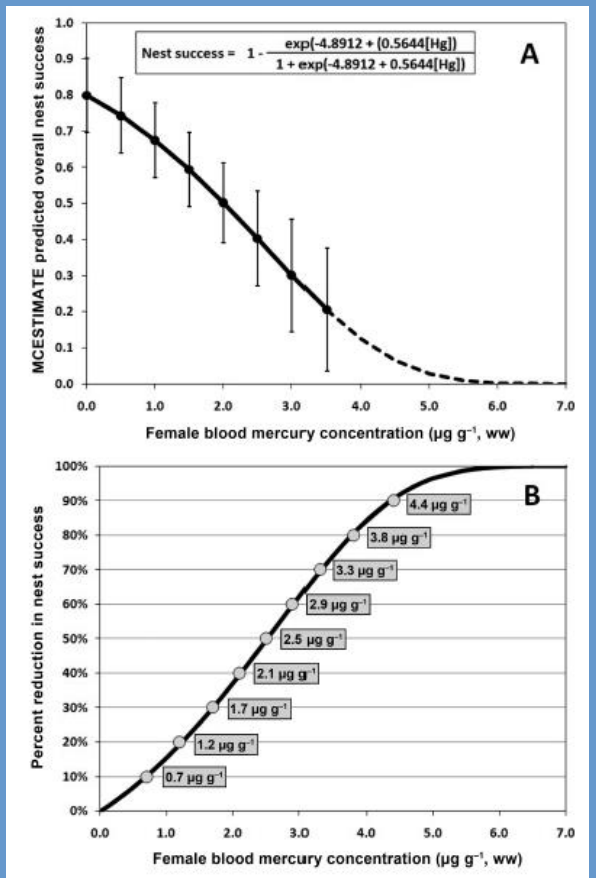


FIG. 5. The relationship between MCESTIMATE-modeled Carolina Wren nest survival and female blood mercury concentration for nests found in 2010 in Virgina. (A) Predicted Carolina Wren nest success over their 30-day nest cycle in relation to female blood mercury concentration when other covariates were held constant (date = 24 May, nest cavity = natural). Error bars indicate SE. Dotted portion of the line indicates model extrapolation past observed female blood mercury concentrations. (B) Percent reduction in nest survival (from nest survival at 0 µg g^{-1}) in relation to female blood mercury concentration. Blood mercury concentrations associated with 10% increments of reduction in nest success are shown.

Jackson et al. 2011

Objectives

- Assess Hg concentrations in Rusty Blackbirds across their range; Where/when is Hg of greatest concern?
- Compare mercury in Rusty Blackbirds with co-occurring species
- Assess long-term trends in mercury in Rusty Blackbirds
- Determine likelihood of Hg as a contributing factor to the population decline
- Determine mechanisms promoting bioaccumulation of Hg in areas with elevated tissue-Hg concentrations

Breeding female Rusty Blackbird

Methods

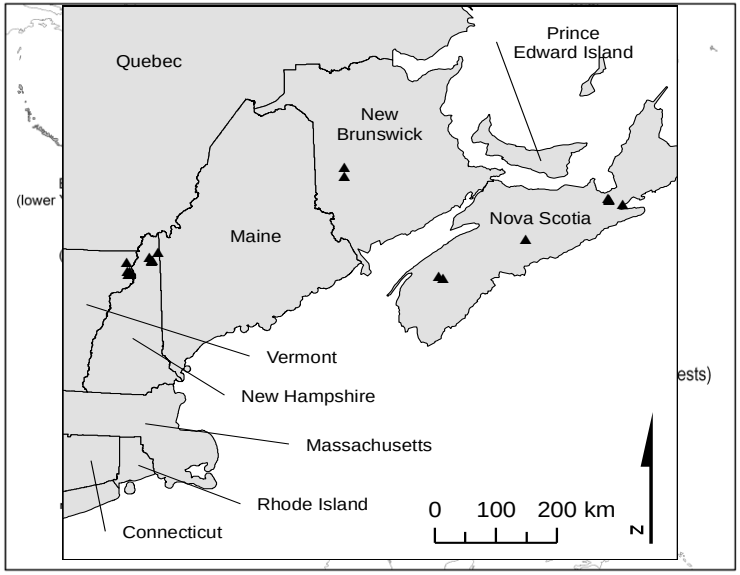
Methods (field):

- Blood/feathers non-lethally collected across range for total-Hg by numerous researchers (2005 to 2012)
- Collected water for MeHg, THg, DOC analysis (2009, 19 sites in Northeast)
- Simultaneously measured pH, redox potential, DO_2, conductivity, temperature (YSI Multi-probe)
- Invertebrates collected for MeHg and THg analysis
- Body feathers collected from museum specimens (Harvard Museum of Comparative Zoology) for MeHg

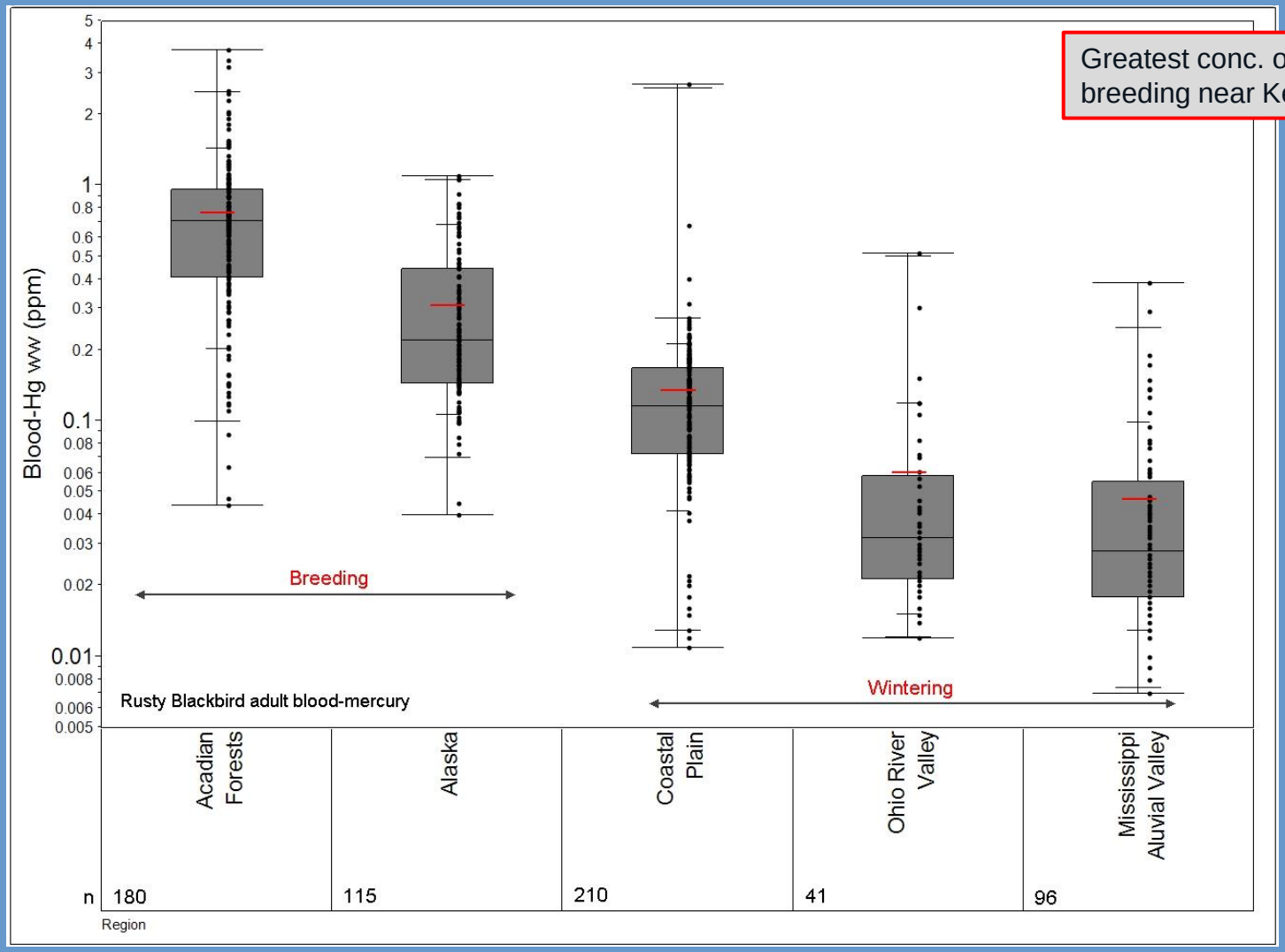
Female Rusty Blackbird having blood drawn for Hg analysis

Methods (lab):

- Bird blood/feather THg analysis by AA
- Invertebrate and body feathers analyzed for MeHg/Hg(II) analyzed after extraction by KOH/MeOH by GC-AFS
- Water THg analyzed after filtering, oxidation to Hg(II) by BrCl, reduction by SnCl2, and purge onto gold traps. Analyzed by AFS
- Water MeHg analyzed after distillation, and purge & trap, by GC-AFS



Rusty Blackbird blood-mercury concentrations



Greatest conc. of 3.77 µg/g THg from a male breeding near Kejimkujik National Park, NS

Blood represents recent uptake/local exposure

- NE Breeding 6x > Winter
- Northeast 3x > Alaska

Significant differences observed between all regions and the Northeast ($p < 0.001$)

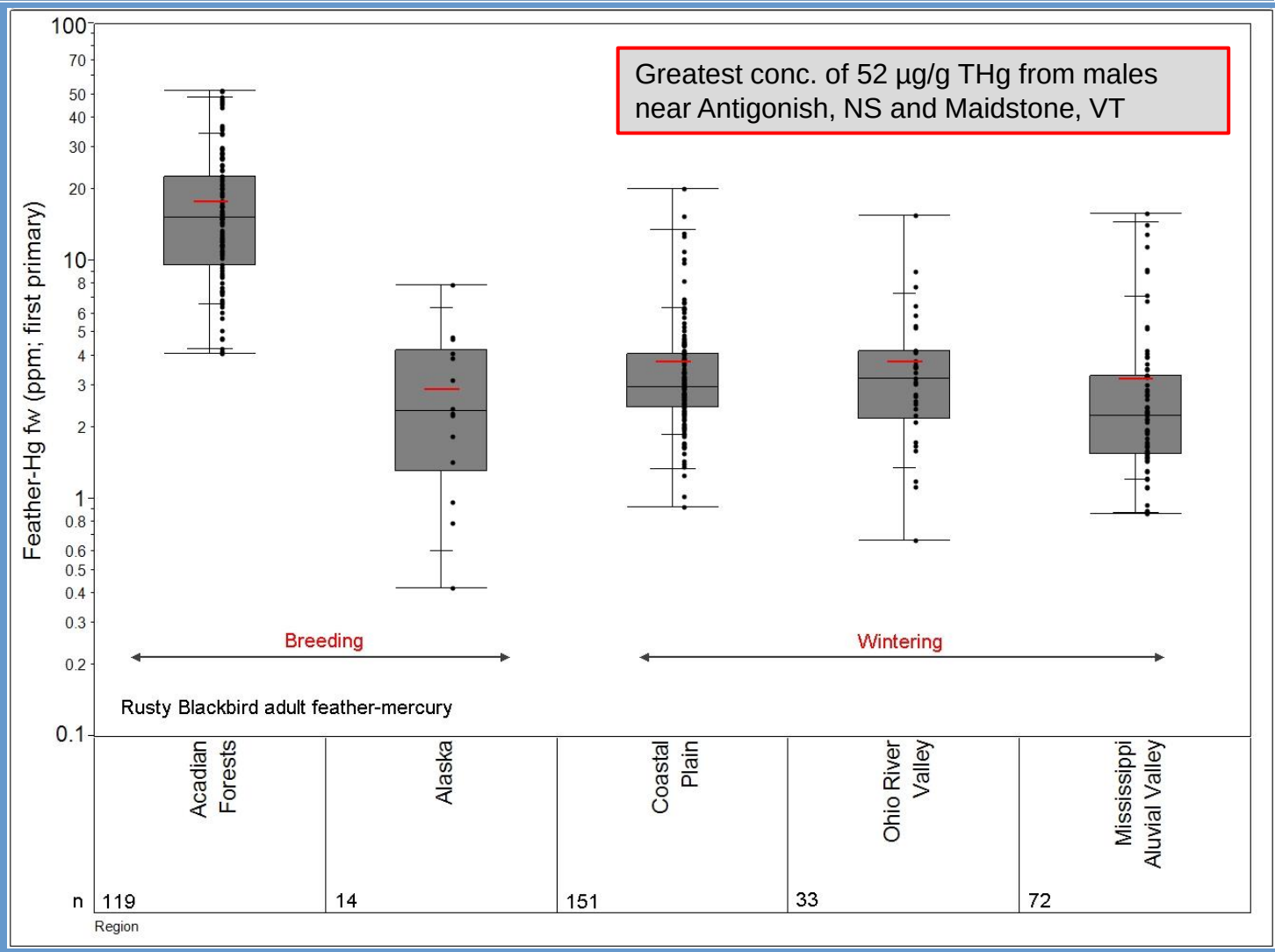
Edmonds et al. 2010. *The Condor,* v.112

Rusty Blackbird feather-mercury concentrations

Feathers roughly represent long-term Hg accumulation

Sequester Hg during growth (post-breeding)

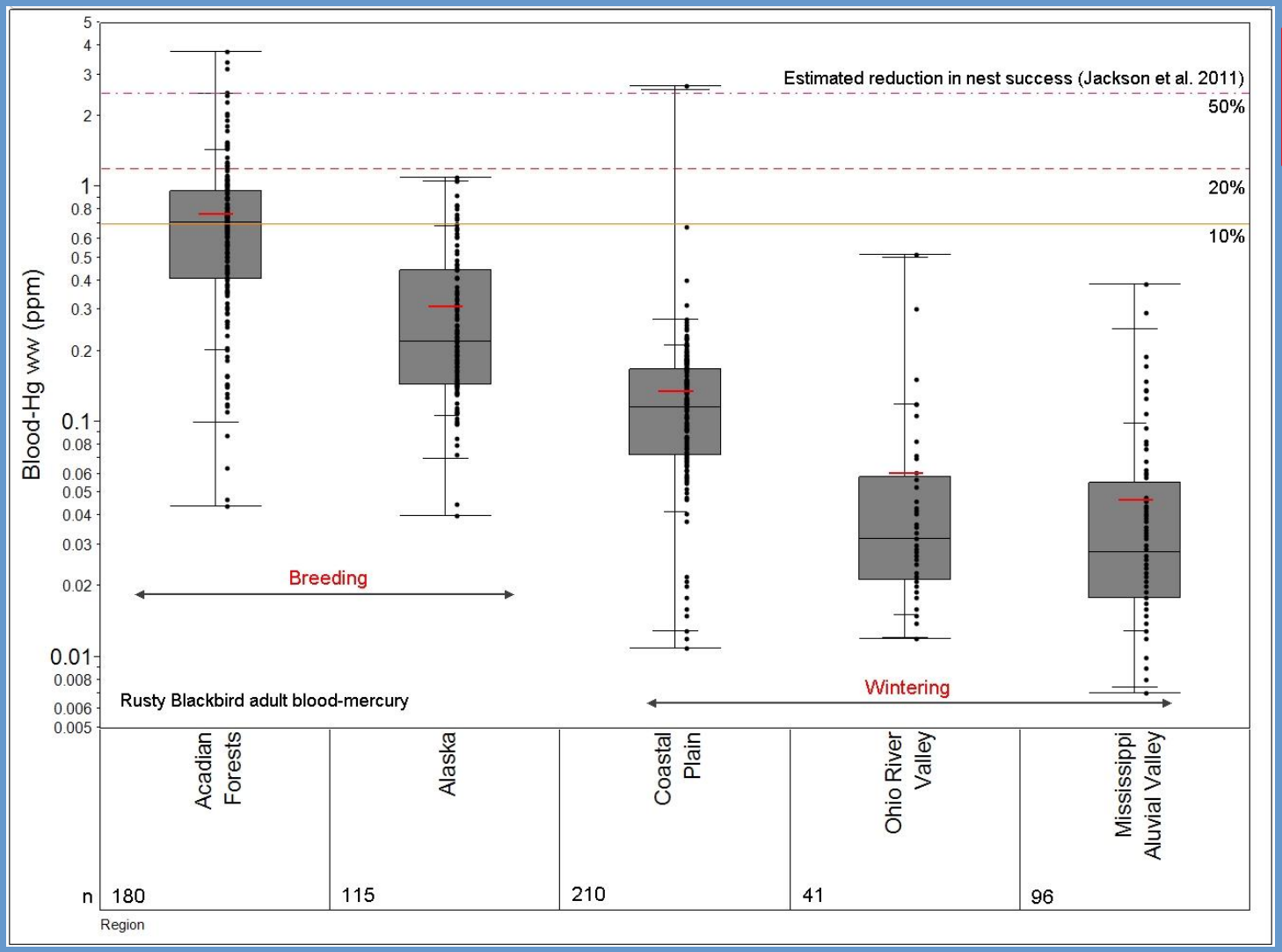
- Feathers from wintering birds suggest similar Hg exposure across breeding range
- But…Northeast at least 3x other regions



Edmonds et al. 2010. *The Condor* 112

Northeast significantly different from the other 4 regions ($p < 0.001$), the other 4 regions were similar ($p > 0.05$)

Rusty Blackbird blood-mercury concentrations



13% of the NE adults exceed 20% threshold

Blood represents recent uptake/local exposure

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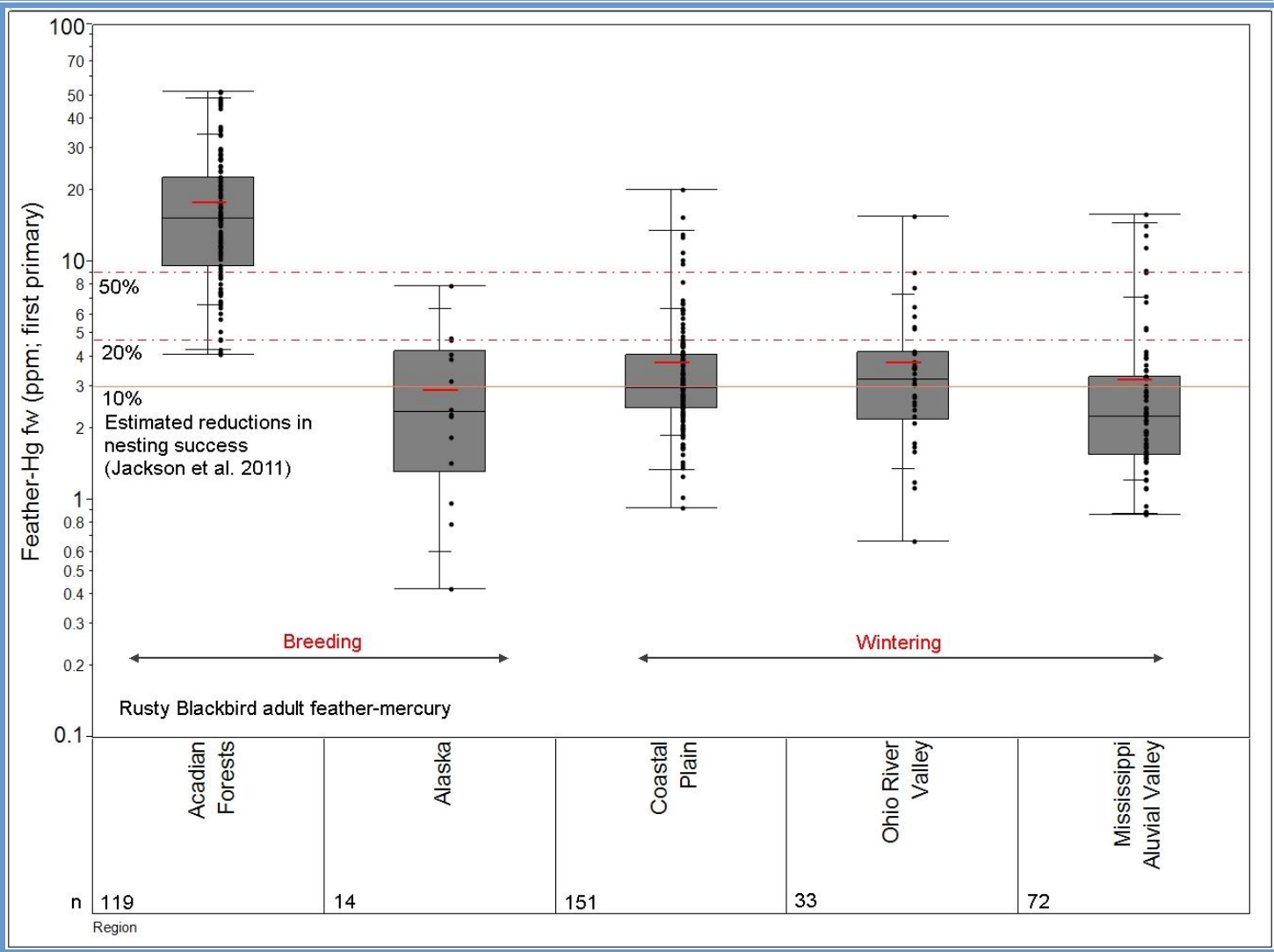
Edmonds et al. 2010. *The Condor,* v.112

Rusty Blackbird feather-mercury concentrations

Feathers roughly represent long-term Hg accumulation

Sequester Hg during growth (post-breeding)

- Feathers from wintering birds suggest similar Hg exposure across breeding range
- But…Northeast at least 4x other regions



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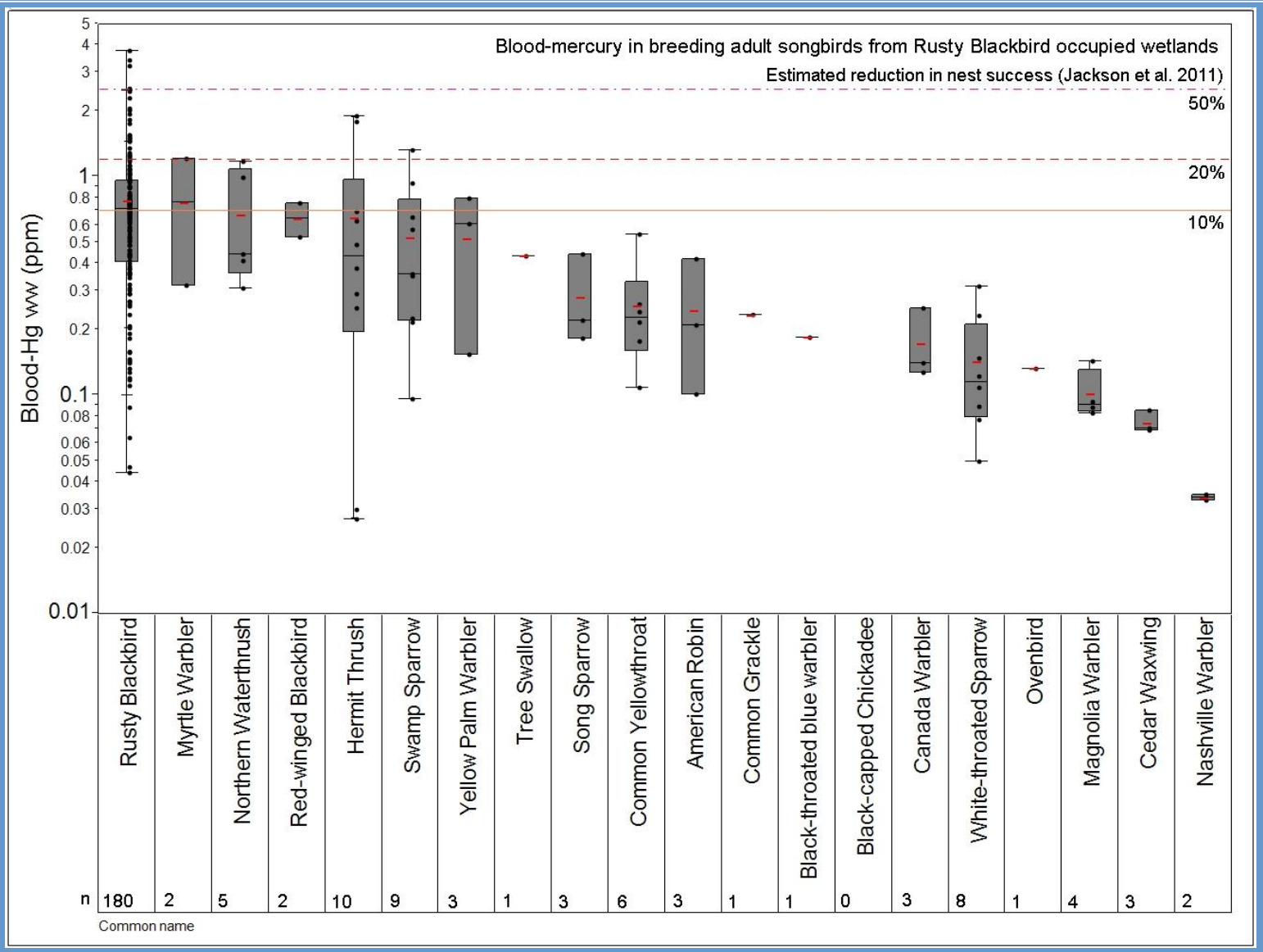
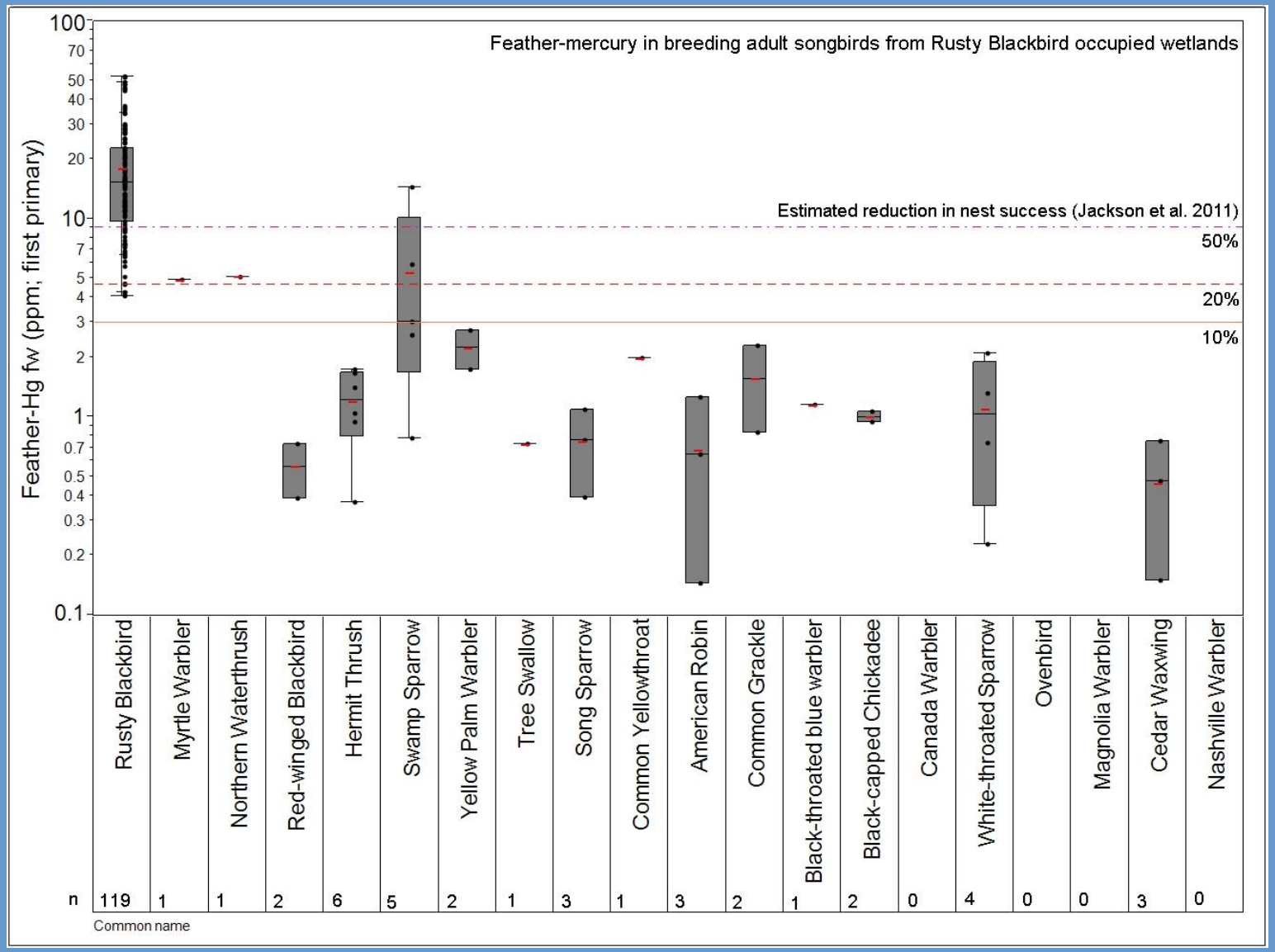
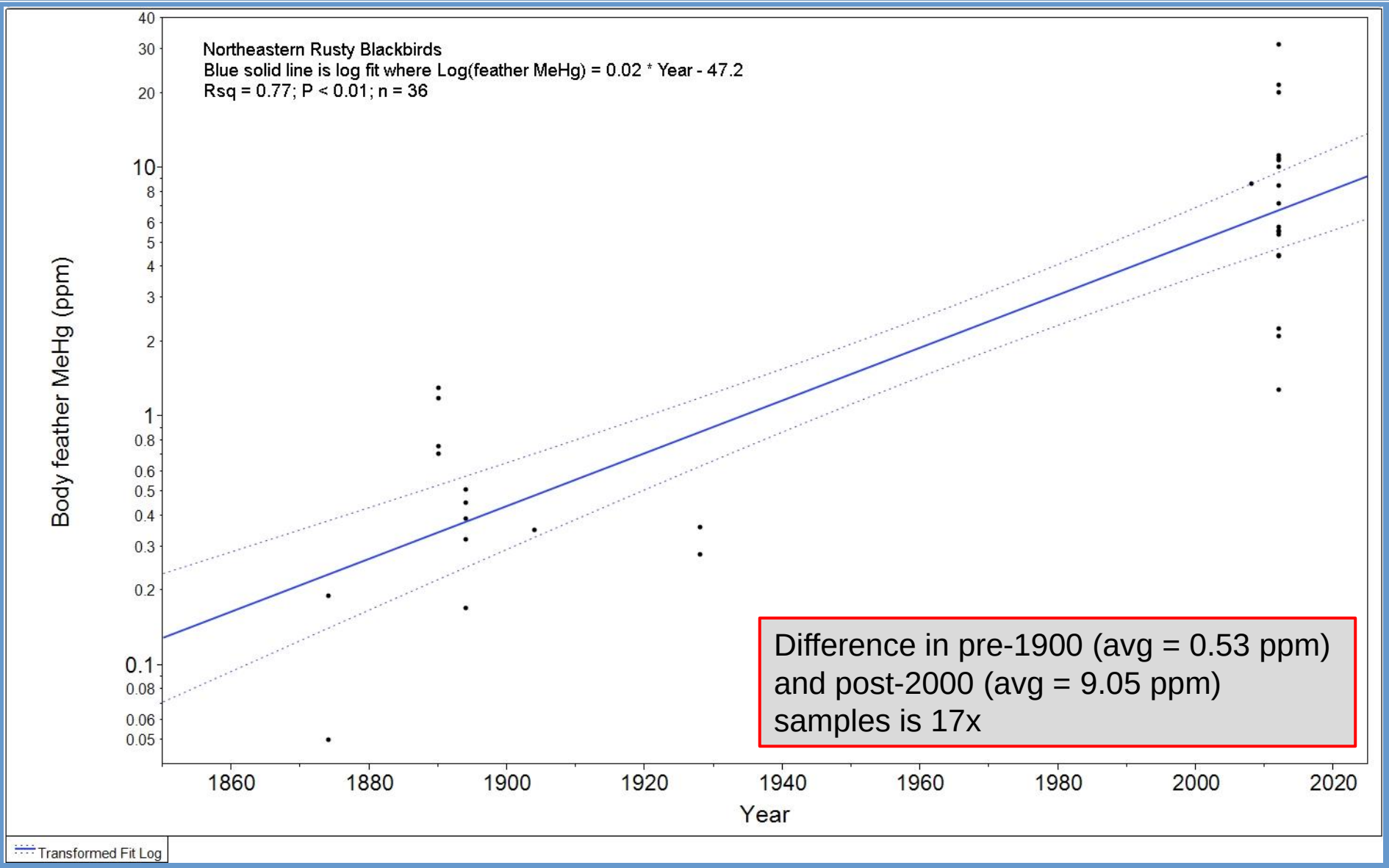
Comparison with co-occurring species: Blood-Hg



Comparison with co-occurring species: Feather-Hg

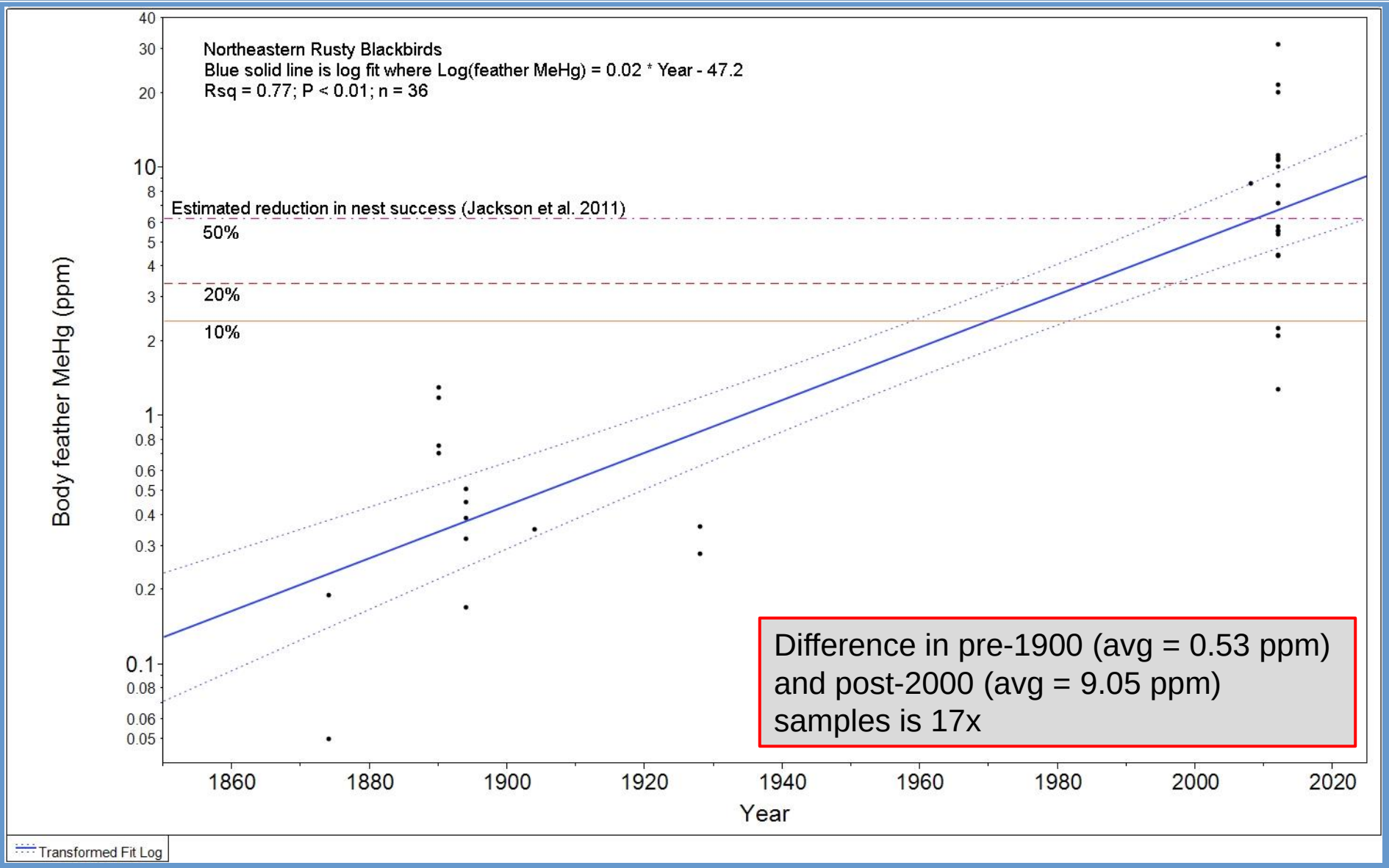


Change in mercury over time



Difference in pre-1900 (avg = 0.53 ppm) and post-2000 (avg = 9.05 ppm) samples is 17x

Change in mercury over time



Difference in pre-1900 (avg = 0.53 ppm) and post-2000 (avg = 9.05 ppm) samples is 17x

Why are Rusty Blackbirds so high in mercury?
(Edmonds et al. 2012)

- Why do mercury concentrations display seasonal differences?
- Why do the Acadian birds have far greater Hg-concentrations than elsewhere?

Rusty Blackbird

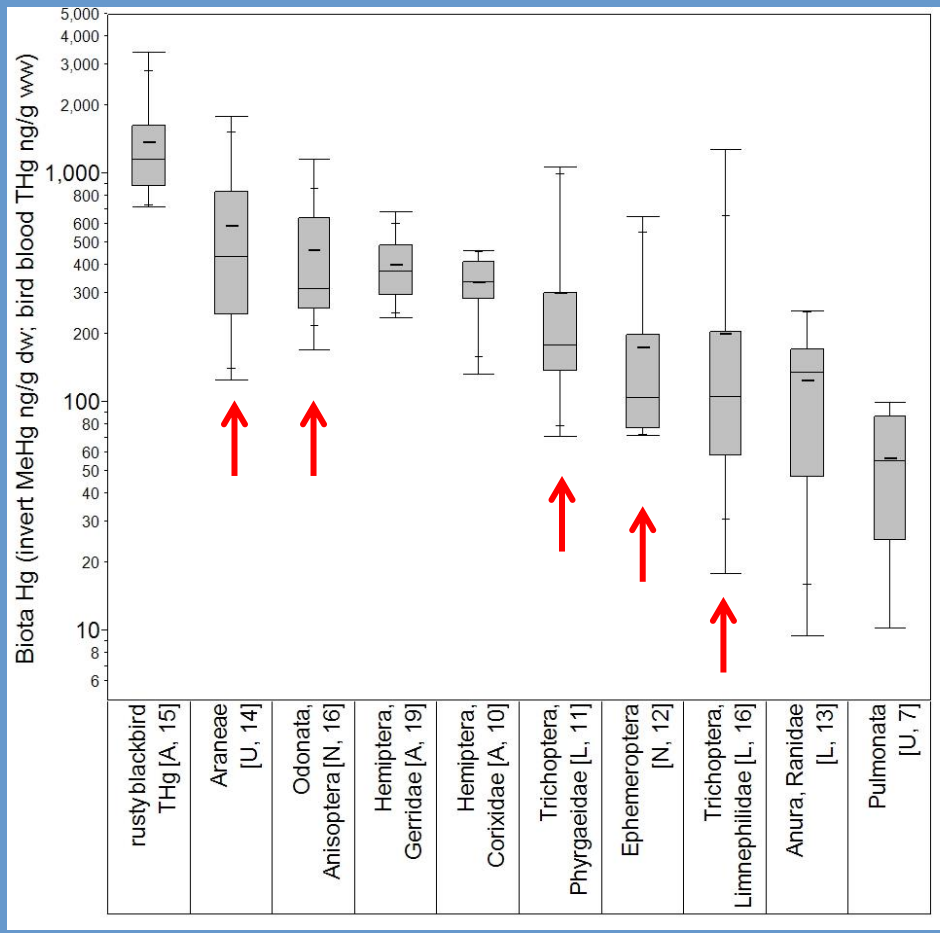
(Icteridae, *Euphagus carolinus*)

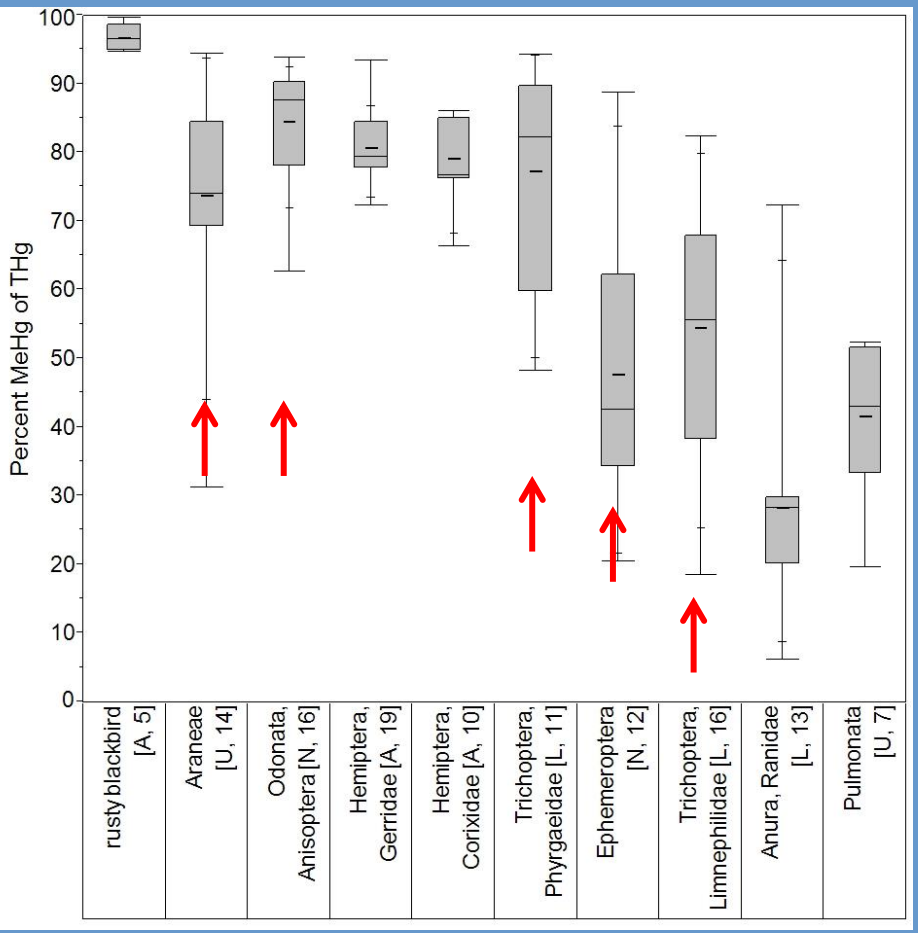
- Breeds in boreal/Acadian forested wetlands
- Breeding diet almost entirely aquatic macroinvertebrate
- Winters in southern U.S., prefers wet bottomlands
- Wintering diet more omnivorous
- ~50 g

Wintering male

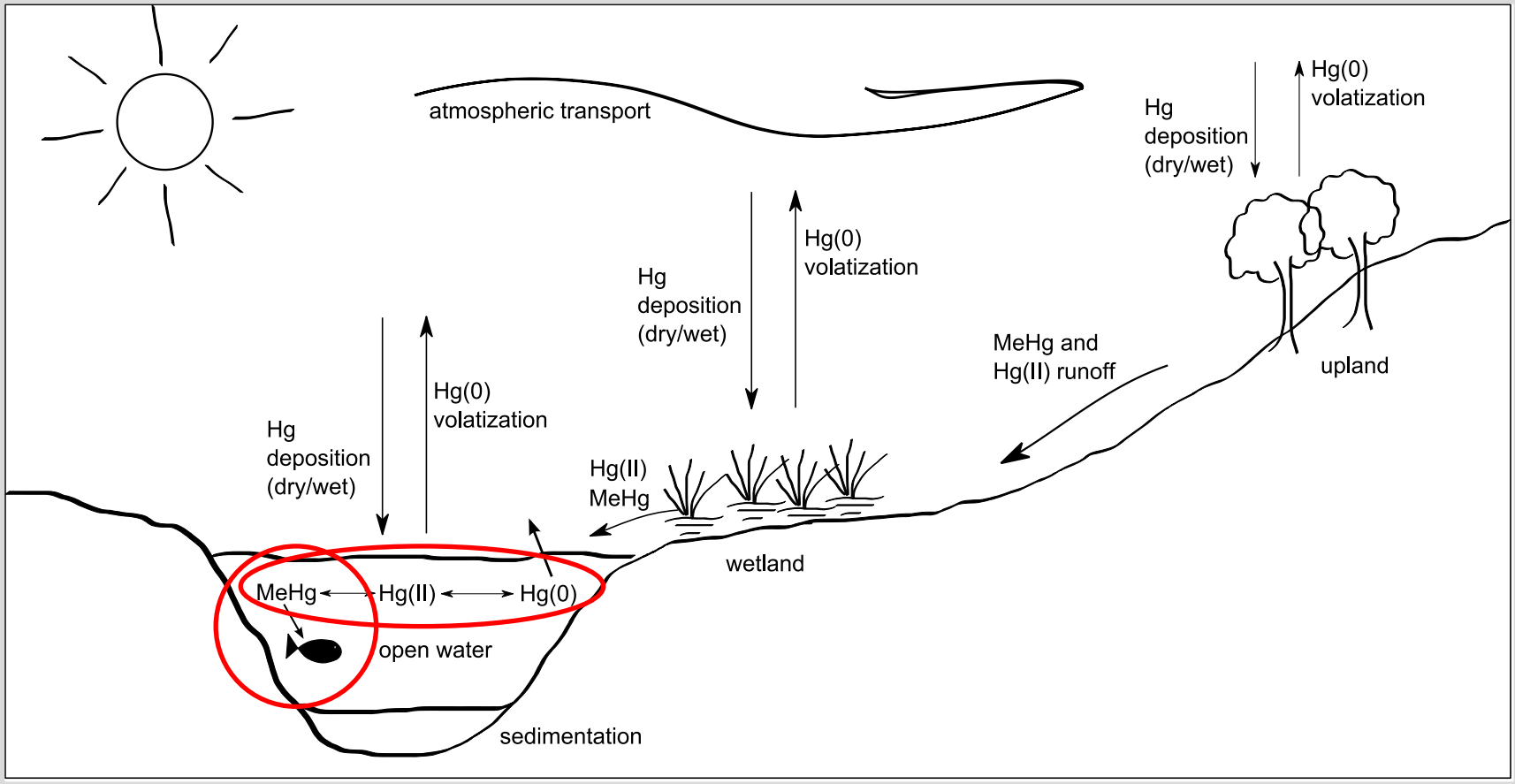
Breeding male

MeHg concentration and %MeHg in blood (ppb ww) and potential prey (ppb dw) of breeding birds





Water quality influences MeHg production and bioavailability; The Mercury Cycle



Breeding wetland in Vermont

Breeding wetland in New Hampshire

Water properties promoting MeHg bioavailability

Primary water characteristics promoting bioavailability (following PCA)

Low DO_2
Low pH
High water MeHg

Interpretation

- Low pH (between 5 and 6) weakens binding affinity of MeHg with sulfide and carboxyl groups on DOC, increasing dissolved MeHg available for uptake
- Low DO_2 increases MeHg production by promoting sulfate- and iron- reducing bacteria; and promotes MeHg solubility. High DO_2 can promote demethylation.

Breeding male Rusty Blackbird

Differences between Alaska (pH > 7) and Northeast (pH between 5 and 6) likely due to differences in pH ---- but needs confirmation

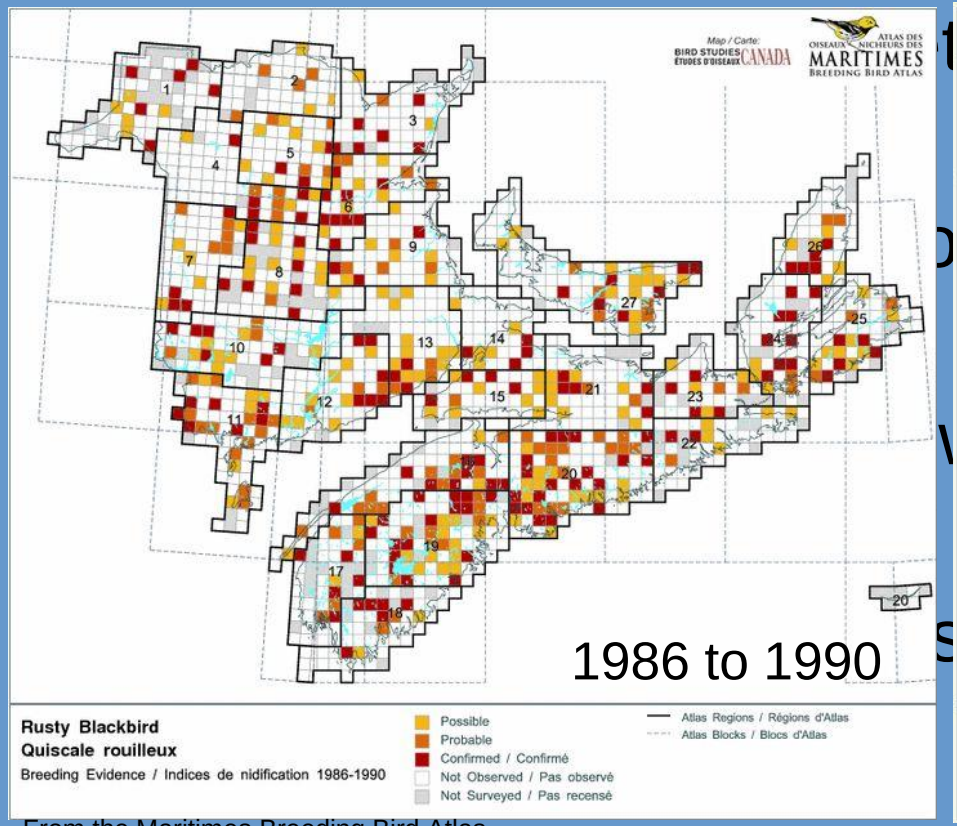
Conclusions

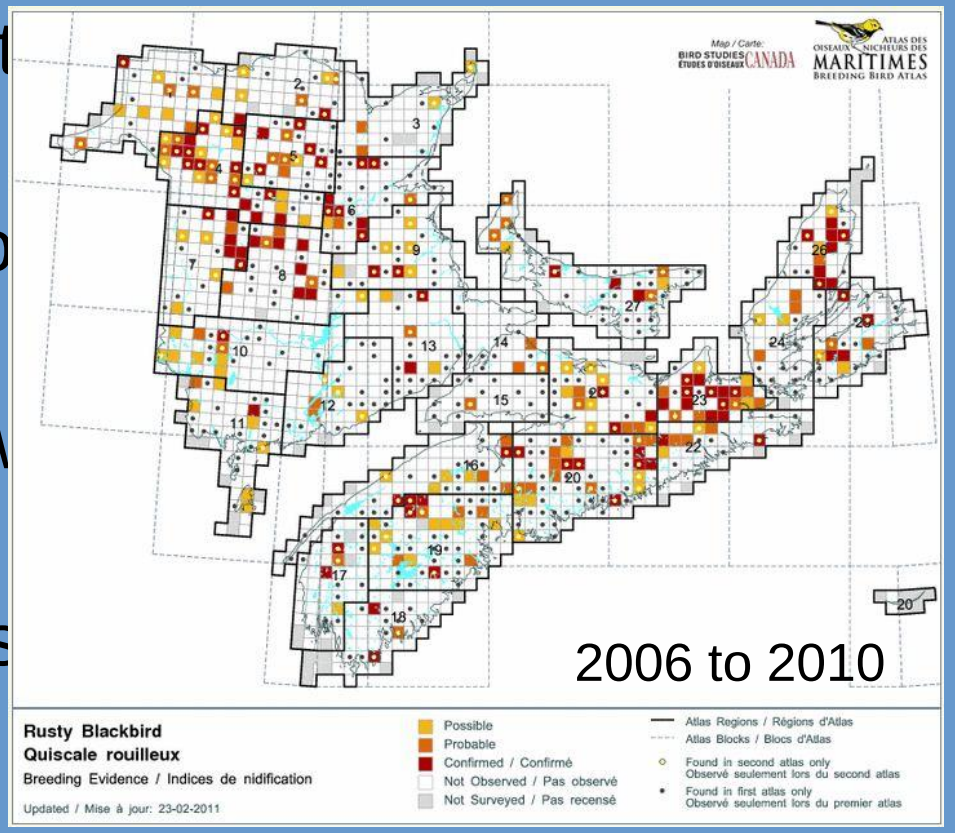
- RUBLs in the Acadian Forests of the Northeast had by far the greatest Hg by region, season, and among species
- Seasonal shift in bird-Hg concentrations likely reflect a shift in diet
- Regional variation in bird-Hg concentrations likely reflect differences in pH (requires confirmation)
- Within the Northeast, MeHg-bioavailability promoted by low pH and low DO_2, and high water MeHg concentration
- RUBLs have increased their Hg burdens by 17x since the late 1800s
- Bird-Hg concentrations in the Northeast exceed estimated levels of concern and should be considered a contributing factor to the on-going population decline

Breeding pair in New Hampshire

What's next?

- Compare BBAs with biota Hg concentrations (fish-Hg) [looking for funding and time]





From the Maritimes Breeding Bird Atlas

Acknowledgements

Data gathered in cooperation with the International Rusty Blackbird Working Group.

Thank you to collaborators, in particular Dan Cristol's group, Carol Foss, Kate Keyden, Russ Greenberg, Claudia Mettke-Hofman, Steve Matsuoka, MBBA, Patti Newell, IRWG researchers, and their numerous technicians; and to Cate Little and Maureen Flinn for help with invert identification. Body feathers for historic Hg trends provided by the Harvard Museum of Comparative Zoology

Funding and/or logistical support provided in part by BRI, NSERC, CRC, CFI, Ducks Unlimited Canada, and K.C. Irving Centre.

Breeding pair in New Hampshire

References:

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Jackson et al. 2011. Mercury exposure affects the reproductive success of a free-living terrestrial songbird, the Carolina Wren (*Thryothorus ludovicianus*). Auk 128:759-769.

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Results: Water chemistry

variable (units)	mean ± SD	median	range
THg (ng L^{-1})	2.87 ± 0.50	2.75	2.12 to 3.94
MeHg (ng L^{-1})	0.48 ± 0.34	0.52	0.02 to 1.05
percent MeHg	17% ± 11%	15%	1% to 35%
DOC (mg L^{-1})	8.65 ± 4.75	7.67	2.12 to 18.98
pH	5.79 ± 0.76	5.86	4.34 to 7.47
DO_2 (mg L^{-1})	6.97 ± 2.82	6.92	1.61 to 11.00
conductivity (mS cm^{-1})	0.09 ± 0.16	0.03	0.02 to 0.50
Redox potential (mV)	66 ± 86	76	-203 to 179
water temp. (°C)	15.55 ± 3.45	15.52	10.92 to 23.11