Western Airborne Selected Contaminants Assessment Program: Focus on PNW Results Compared and Interpreted

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PNW NPS Workshop – Seattle, WA – 4-5 Nov. 2010

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WACAP Highlights for OLYM, MORA and NOCA

- 4 lakes in OLYM and MORA are similar in many ways: low productivity, dilute, small watersheds. MORA lakes had lowest SO4, most dilute and lower ANC. PJ Lake is an outlier in many ways, routinely disturbed due to debris flows, avalanches, lots of large wood, more productive, higher in pH, ANC and Sp. Conductance.
- Very similar air shed influences. >30% of annual ppt. from SW. Highest ppt. in winter (snow AND rain). OLYM had highest Hg in snowpack (only 2004 sampled). Endosulfans, a-HCH and HCB were detected in both parks in Passive Air Samplers. No East – West differences between air samplers in MORA.
- *Hg concentrations in snowpack worth a closer look – PNW Snow??
- Vegetation in OLYM, MORA and NOCA were in the mid to upper ranges for SOC and Hg. Dominant contaminants in conifers were PAHs, Endosulfans, a-HCH, HCBs, and Dacthal. Lichen and Conifer SOCs were similar in types detected and concentrations.
- *Possible concern due to conifer needle fall in both parks
- Fish tissue concentrations in OLYM were low for dieldren, mirex, and chlordanes. Hg concentrations were among the highest for all Parks. Hg exceeded the thresholds for piscivorous mammals, birds and, in all four lakes, some individual fish for human consumption thresholds. There was a significant correlation between [Hg] and macrophage aggregates in fish spleen and kidney.
- MORA Golden Lake had the highest PBDE concentrations in fish in the entire WACAP study. Seattle air shed influence may be responsible. Dieldren in average fish exceeded subsistence human thresholds in Golden Lake and for some individual fish in LP19. Hg exceeded fish contaminant thresholds for piscivorous birds and mammals. Hg and MAs were correlated in LP19 (spleen and kidney).
- Sediments had many SOCs below detection except PAH and PCB. SCPs peak in the 50s and 60s and decrease to present time – demonstrating reduced sources. Hg profiles tend to increase from 1900 or 1920 to present and lead profiles are similar. The increase in Hg near the surface may be due to increased global background concentration and flux from the atmosphere or due to global warming mobilizing Hg from watersheds. This latter concept may be supported by the similarity between Total Organic Carbon and Hg profiles in several lakes.
- *Sediment relationships between TOC and Hg could be further explored along with temperature records in selected lakes.

WHY WACAP?

1.3 million metric tons of pesticides used in China (WHO)

2600 metric tons of Hg emitted into the air from anthropogenic sources (UNEP)

Between ‘92-’94 the US exported at least 30,000 metric tons of banned pesticides to the developing world (AAAS)

Flame retardants 10-1000 fold higher in American’s breast milk compared to Europeans (EHP)

300,000 American newborns at risk from Hg toxicity (CDC)

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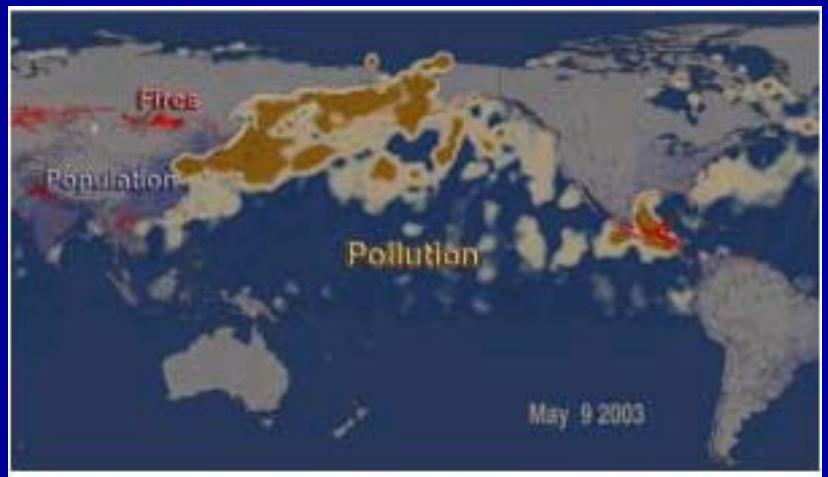
How much of the contaminants in North America are from Trans-Pacific Transport?



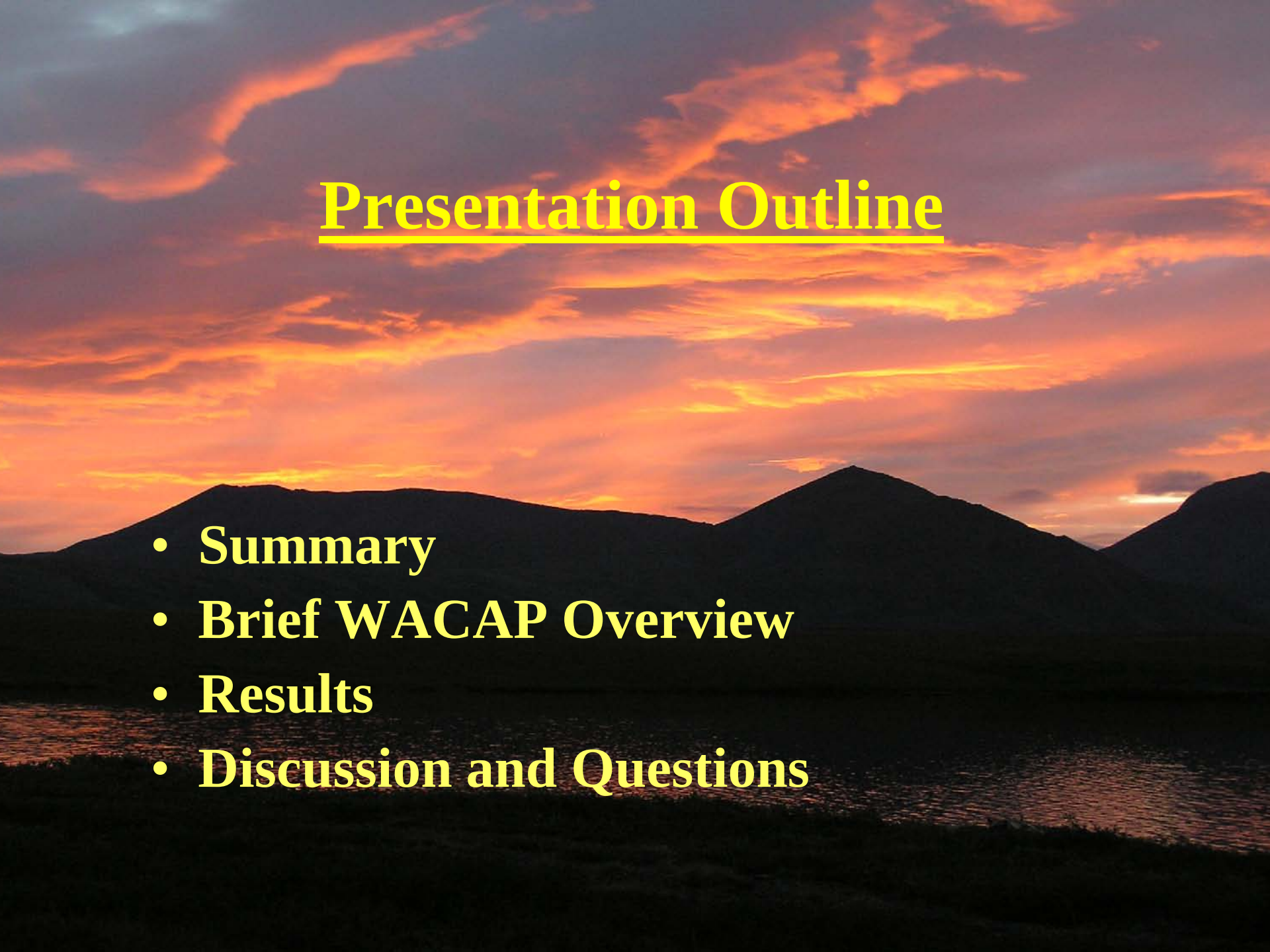
In a new NASA study, researchers taking advantage of improvements in satellite sensor capabilities offer the first measurement-based estimate of the amount of pollution from East Asian forest fires, urban exhaust, and industrial production that makes its way to western North America. (Credit: Image courtesy of NASA/Goddard Space Flight Center)

"We used the latest satellite capabilities to distinguish industrial pollution and smoke from dust transported to the western regions of North America from East Asia. Looking at four years of data from 2002 to 2005 we estimated the amount of pollution arriving in North America to be equivalent to about 15 percent of local emissions of the U.S. and Canada,"

"Our study focused on East Asian pollution transport, but pollution also flows from Europe, North America, the broader Asian region and elsewhere

"So we should not simply blame East Asia for this amount of pollution flowing into North America."

http://www.sciencedaily.com/releases/2008/03/080317164336.htm



Presentation Outline

- Summary
- Brief WACAP Overview
- Results
- Discussion and Questions

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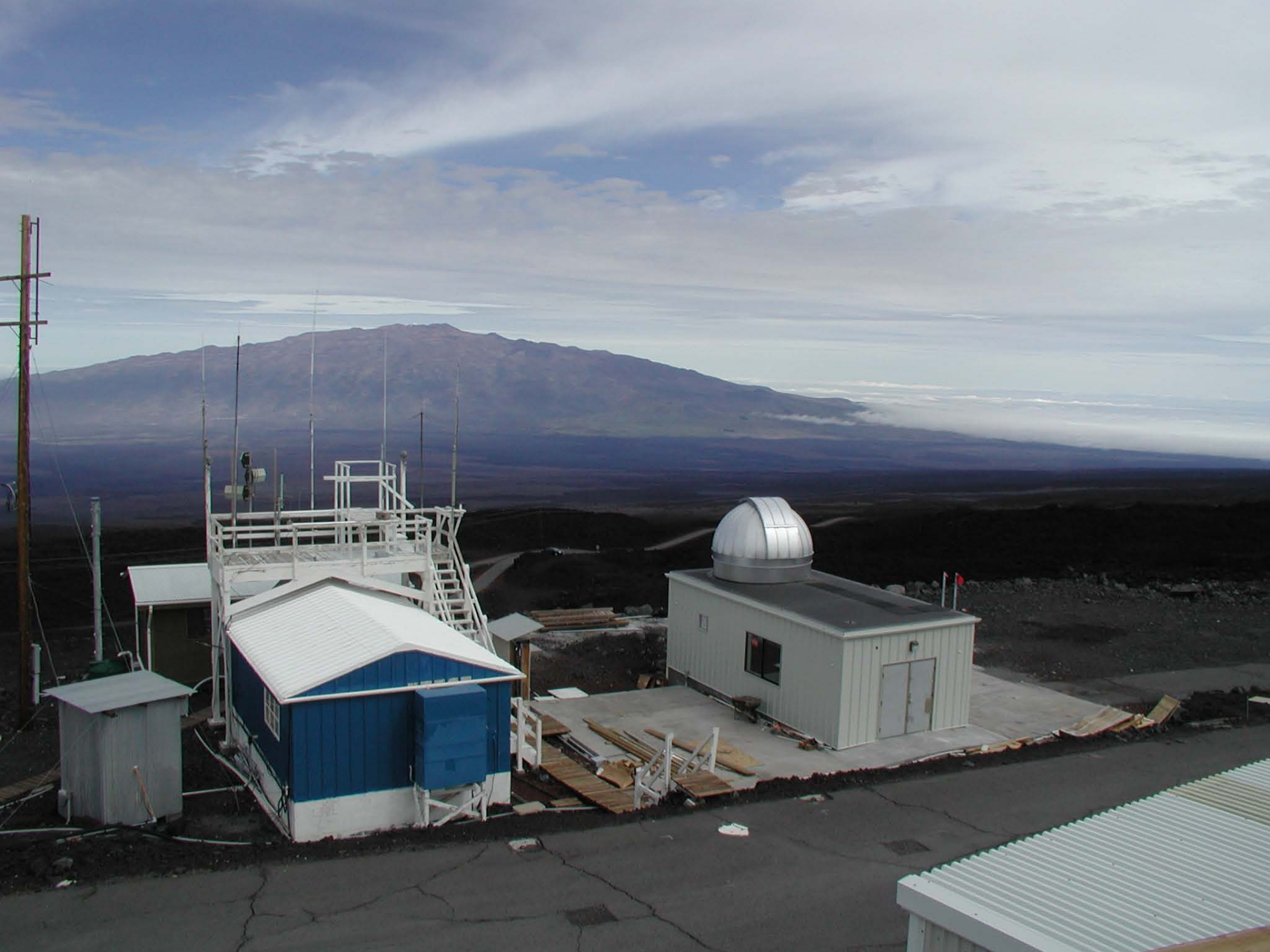
WACAP GOAL:

TO ASSESS THE DEPOSITION OF AIRBORNE CONTAMINANTS IN WESTERN NATIONAL PARKS, PROVIDING REGIONAL AND LOCAL INFORMATION ON EXPOSURE, ACCUMULATION, IMPACTS AND PROBABLE SOURCES



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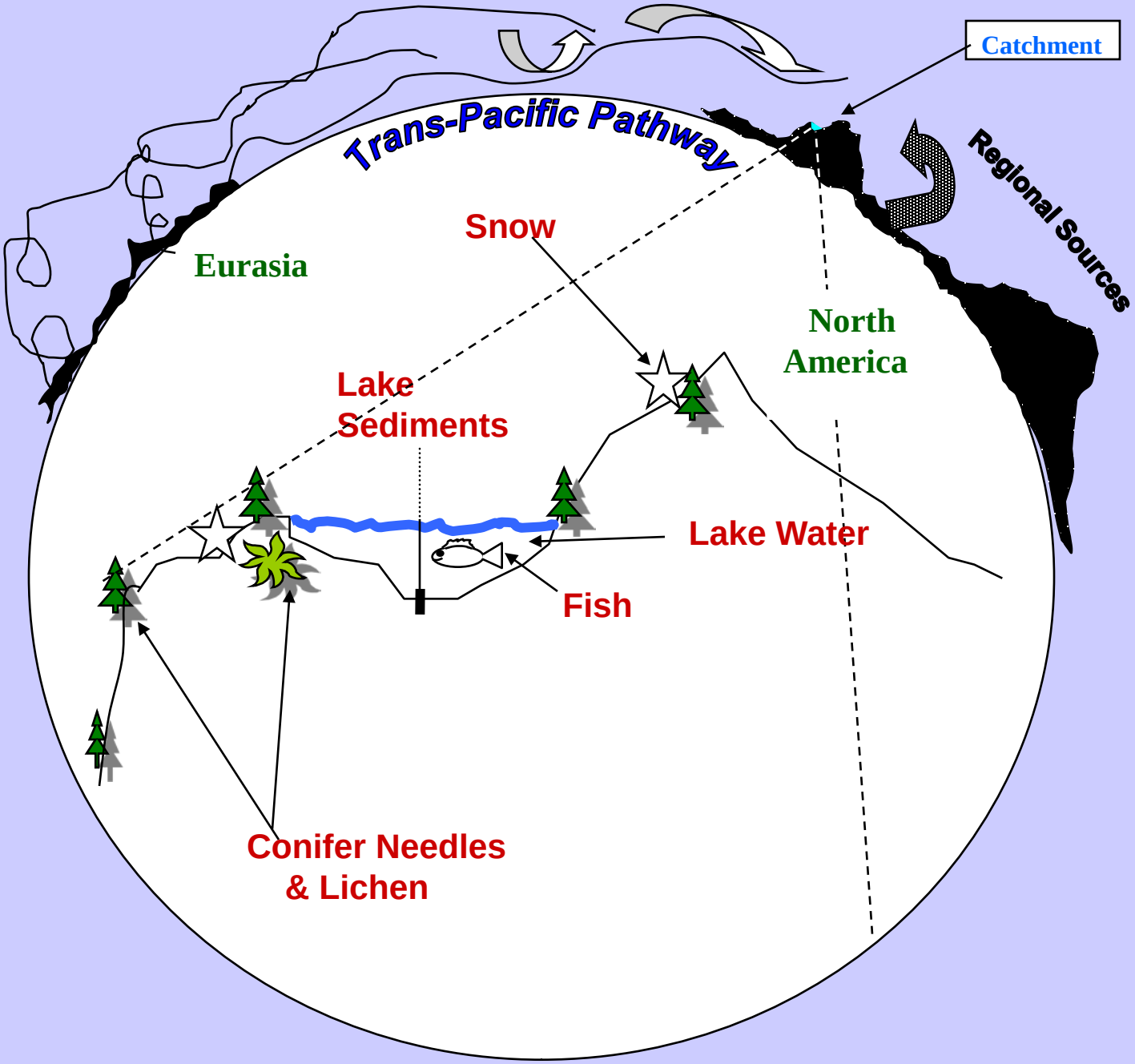
Pear Lake, CA, Sequoia-Kings Canyon National Park, 2908 m.a.s.l.



WACAP Indicators and Conceptual Diagram

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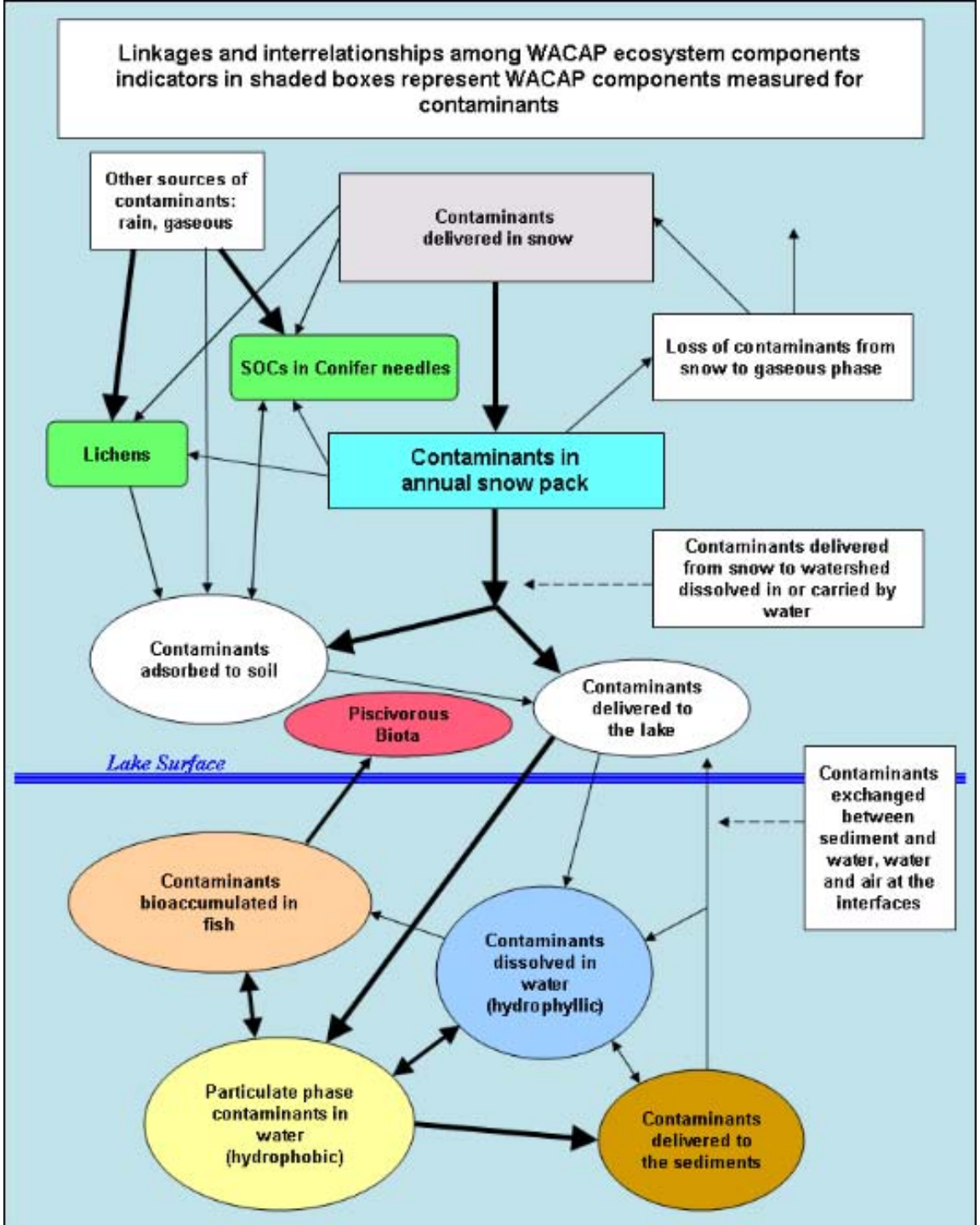
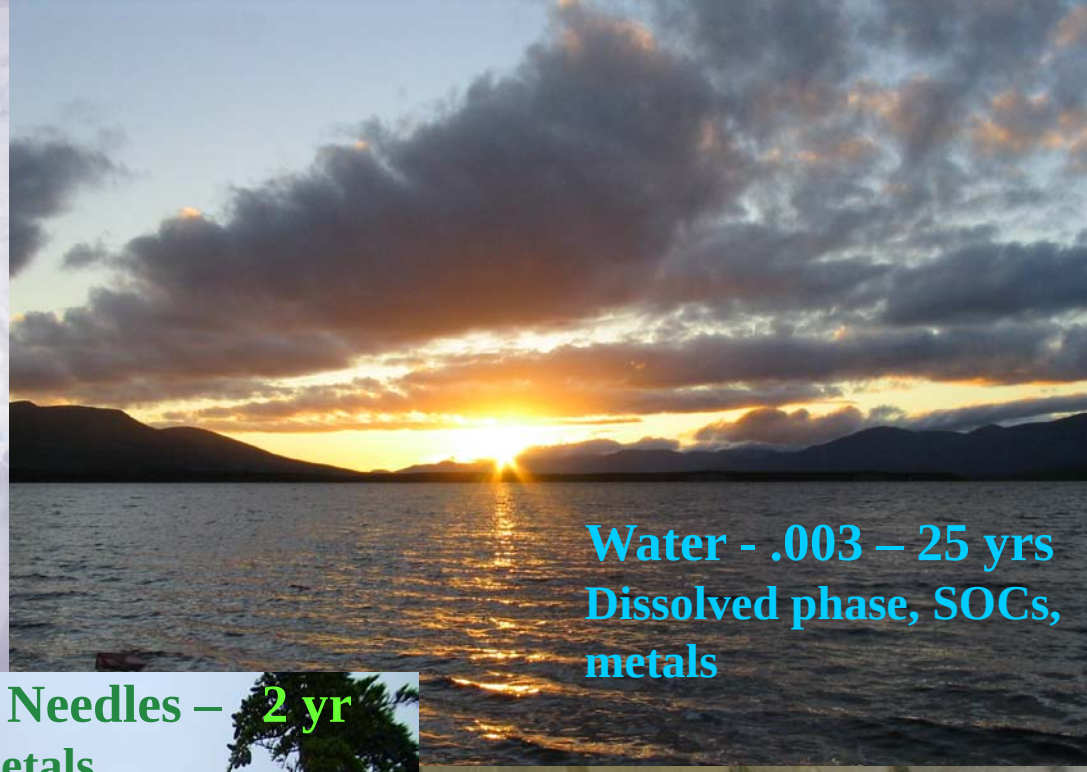


Snow – annual flux SOCs and metals


Water - .003 – 25 yrs
Dissolved phase, SOCs, metals

Lake Sediment ~ 135 y
Chronology
SOCs, metals, SCPs

Conifer Needles – 2 yr
SOCs, metals
Lichen – unknown age
N, S, metals

Fish: 2 – 34 yr (selectable)
SOCs, metals, condition, enzymes, pathology

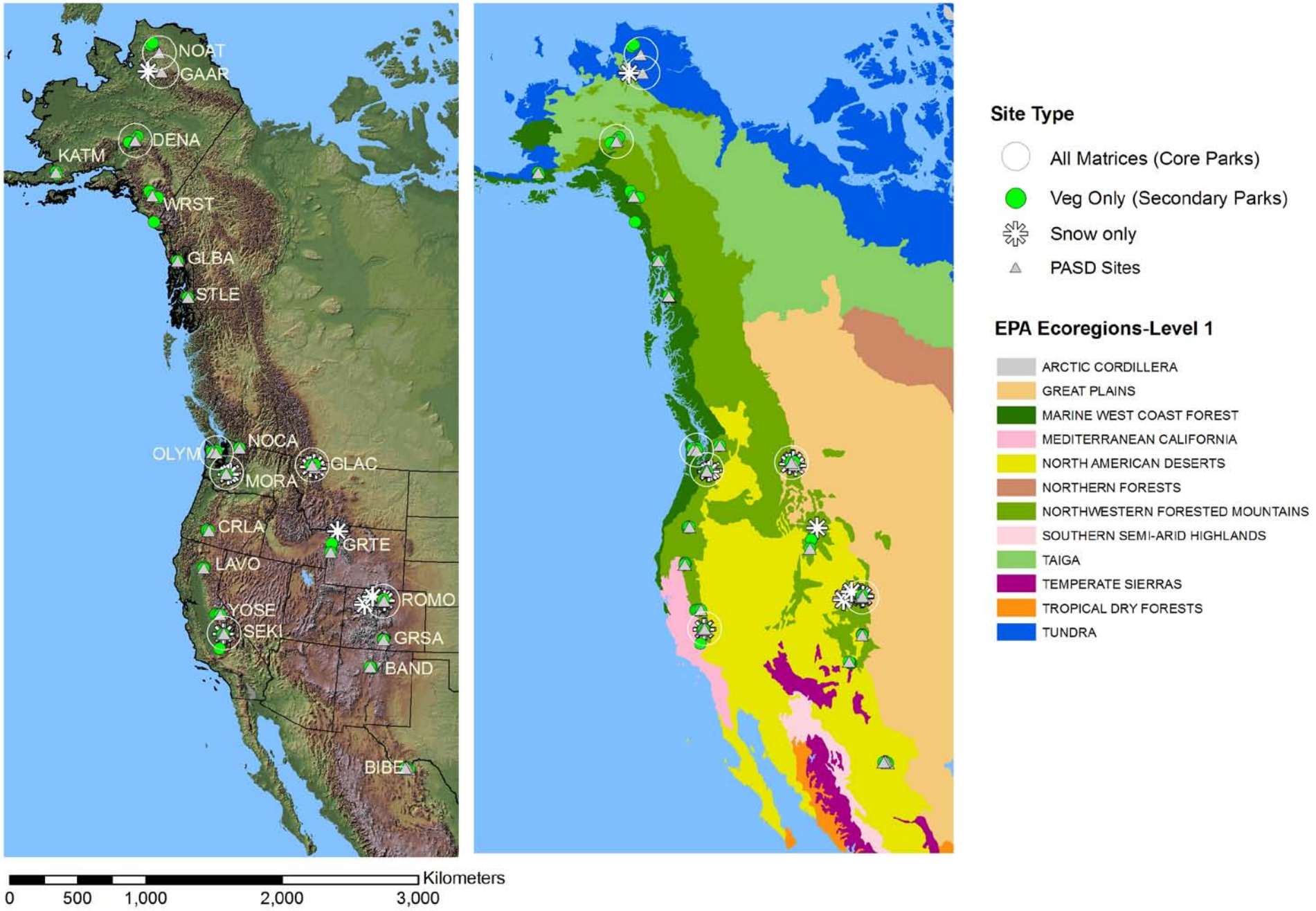


Figure 1. WACAP Sites mapped on North American shaded relief map and EPA Level 1 Ecoregions (Biomes).

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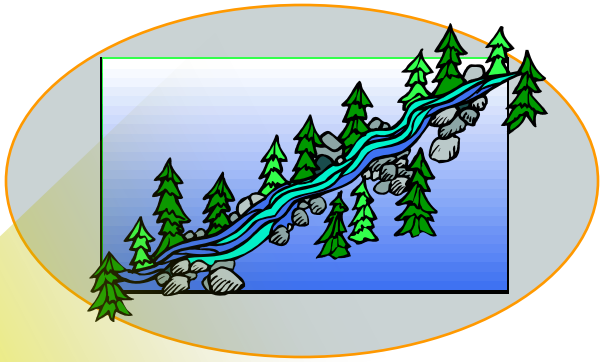
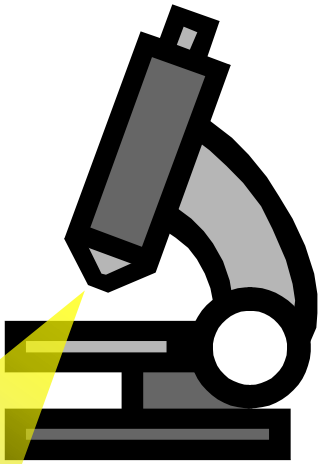
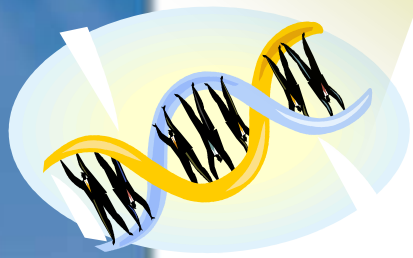


Macroscope



NEED TO UNDERSTAND AT MULTIPLE SCALES



Microscope

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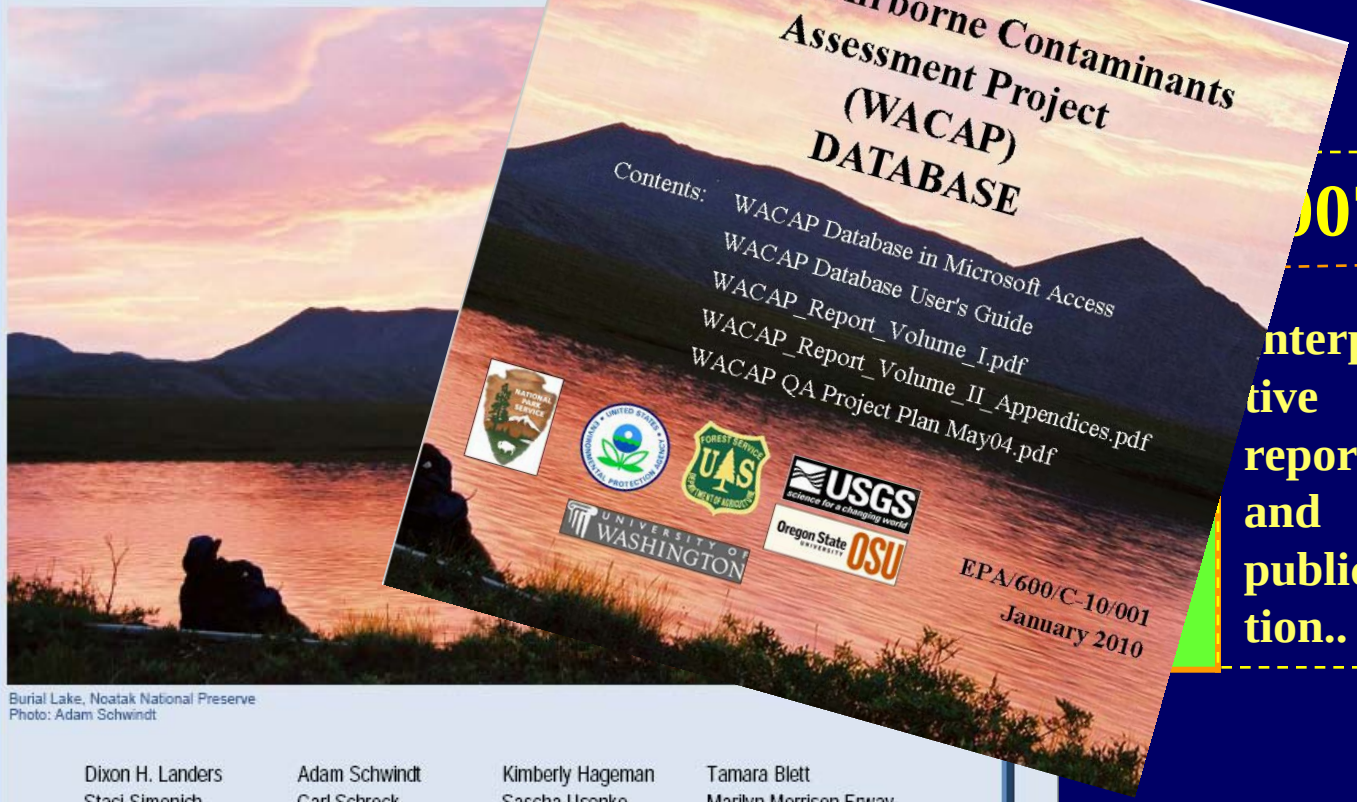
WESTERN AIRBORNE CONTAMINANTS ASSESSMENT PROJECT FINAL REPORT: VOLUME I

The Fate, Transport, and Ec gical Impacts of Airborne Conta in Western National



Burial Lake, Noatak National Preserve
Photo: Adam Schwindt

Dixon H. Landers, Staci Simonich, Daniel Jaffe, Linda Geiser, Donald H. Campbell, Adam Schwindt, Carl Schreck, Michael Kent, Will Hafner, Howard E. Taylor, Kimberly Hageman, Sascha Usenko, Luke Ackerman, Jill Schrlau, Neil Rose, Tamara Blett, Marilyn Morrison Erway

Technical Editor: Susan Christie

EPA/600/R-07/138
January 2008

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What are the contaminant categories of potential risk to the Western National Parks due to the deposition of airborne contaminants?

- Current Use Pesticides (CUPS)
- Historic Use Pesticides (chemicals) HUPS (i.e. POPs)
- Mercury (and other metals)
- Emerging Chemicals (PBDE)

Target Semi-Volatile Organic Compounds

Electron Impact Ionization

PAHs: Acenaphthylene, Acenaphthene, Fluorene, Phenanth… Pyrene, Retene, …phenylene, Benzo[b… …ene, Benzo[e]pyrene, Benzo[a]pyrene, Indeno[1,2,3-cd]pyrene, Dibenz[a,h]anthracene, Benzo[ghi]perylene

Combustion

Pesticides and degradation products:

o,p'-DDT*, p,p'-DDT, o,p'-DDD*, p,p'-DDD, o,p'-DDE, … Ethion, Etradia… Methyl - Parathi… xychlor, Acetochlor*, Alachlor, Prometon, Pebulate, EPTC, Carbofuran, Carbaryl, Propachlor, Atrazine and degradation products, Simazine, Cyanazine

Agriculture

Surrogates: d_{10}-Fluorene, d_{10}-Phenanthrene, d_{10}-Pyrene, d_{12}-Triphenylene, d_{12}-Benzo[a]pyrene, d_{12}-Benzo[ghi]perylene, d_{14}-EPTC, d_{10}-Phorate, d_5-Atrazine, d_{10}-Diazinon, d_7-Malathion, d_{10}-Parathion, d_8-p,p'-DDE, d_8-p,p'-DDT, d_6-Methyl Parathion, d_{13}-Alachlor, d_{11}-Acetochlor

Internal Standards: d_{10}-Acenaphthene, d_{10}-Fluoranthene, d_{12}-Benzo[k]fluoranthene

Electron Capture Negative Ionization

PCBs:

PCB 74 (2,4,4',5-Tetrachlorobiphenyl),
PCB 101 (2,2',4,5,5'-Pentachlorobiphenyl),
PCB 118 …),
PCB 138 …yl),
PCB 153 (2,2',4,4',5,5'-Hexachlorobiphenyl),
PCB 183* (2,2',3,4,4',5',6-Heptachlorobiphenyl),
PCB 187 (2,2',3,4',5,5',6-Heptachlorobiphenyl)

Industry

Pesticides and degradation products:

Hexachlorocyclohexanes (HCH) - α*, β, γ-(lindane), and δ, Chlordanes - cis*, trans*, oxy*, Nonachlor – cis, trans, Heptach… ulfans - I, II, and sulf… in Aldehyde, Hexachlorobenzene, Dacthal, Chlorothalonil, Chlorpyrifos and oxon, Trifluralin, Metribuzin, Triallate, Mirex

Agriculture

Surrogates: $^{13}C_{12}$ PCB 101 (2,2',4,5,5'-Pentachlorobiphenyl), $^{13}C_{12}$ PCB 180 (2,2', 3,4,4',5,5'-Heptachlorobiphenyl), d_{10} - Chlorpyrifos, $^{13}C_6$-HCB, d_6-γ-HCH, d_4-Endosulfan I, d_4-Endosulfan II, d_{14}-Trifluralin

Internal Standard: $^{13}C_{12}$ PCB 138 (2,2',3,4,4',4',5'-Hexachlorobiphenyl)

LIFE-LINK

BROOKS RANGE AVIATION
Beaver
N4040N

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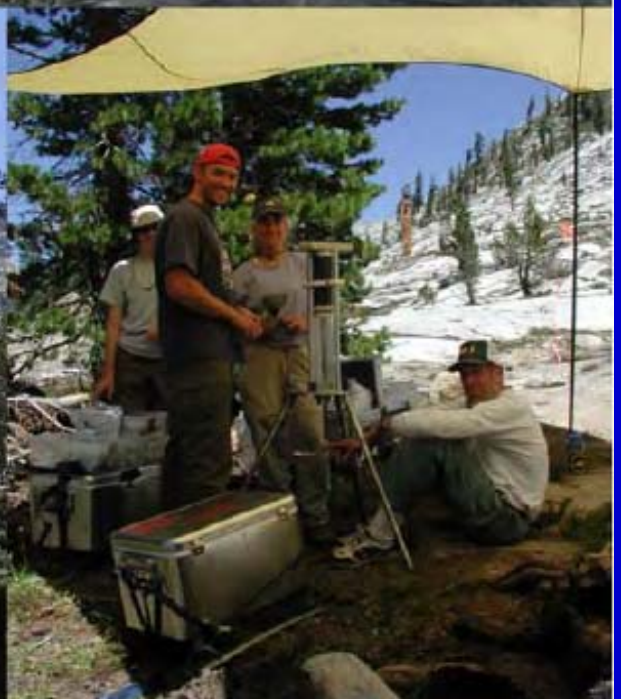
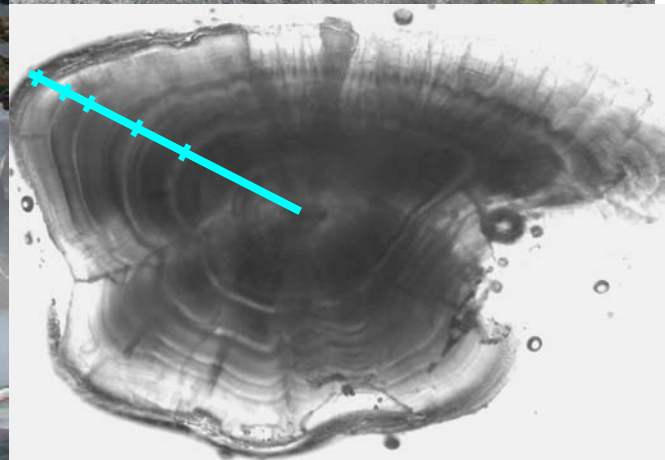
Sequoia and Kings Canyon National Parks





WACAP Results:

(Sediments and Source Allocations With a PNW perspective)

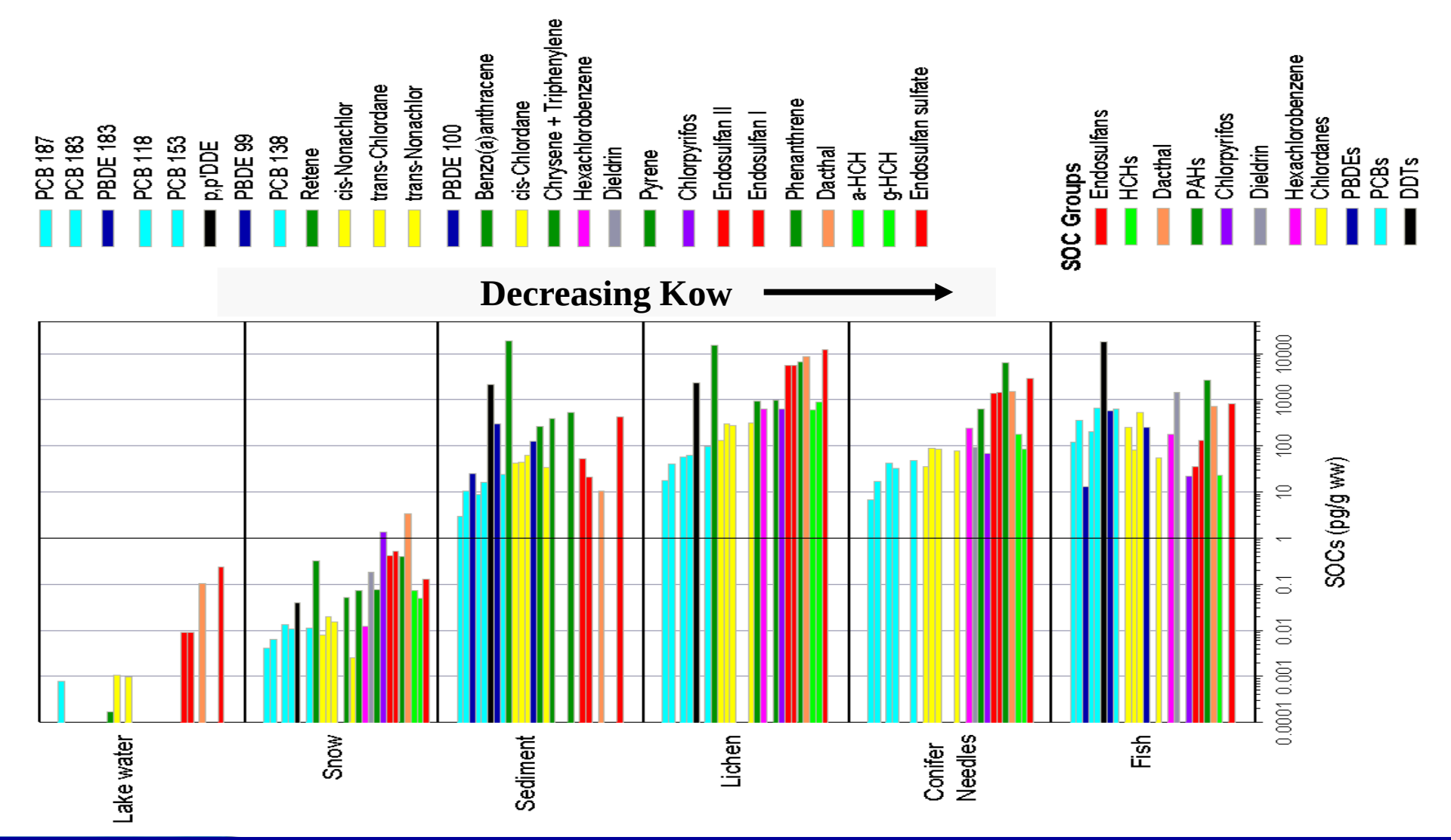


Figure 2. Mean SOC Concentrations (pg/g ww) in Lake Water, Snow, Sediments, Lichens, Conifer Needles, and Fish from Emerald Lake (SEKI). SOCs are ordered by increasing Kow, or decreasing polarity and solubility in water, color-coded by group. SOC concentrations were 3 to 7 orders of magnitude higher in sediments and biota relative to snow and water. SOC concentrations in water, snow, and vegetation, but not sediments and fish, generally decreased with decreasing polarity. Compared to vegetation, fish were better accumulators of PCBs and dieldrin and poorer accumulators of PAHs, endosulfans, HCHs, dacthal, and chlorpyrifos. If no data are shown, all samples were below detection limits; PBDEs were measured in sediments and fish only.

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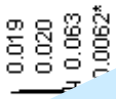
Current Use Pesti



ES&T March 2008

Atmospherically Deposited PBDEs, Pesticides, PCBs, and PAHs in Western U.S. National Park Fish: Concentrations and Consumption Guidelines

LUKE K. ACKERMAN,†
ADAM R. SCHWINDT,‡ STACI L. MAS
SIMONICH,*,†,§ DAN C. KOCH
TAMARA F. BLETT,⊥ CARL B. S
MICHAEL L. KENT,‡ AND
DIXON H. LANDERS#

park for the tou
e pesticides.

Historic Use Pesticides

ES&T February 2008

Mercury Concentrations in Salmonids from Western U.S. National Parks and Relationships with Age and Macrophage Aggregates

ADAM R. SCHWINDT,
JOHN W. FOURNIE,
DIXON H. LANDERS,
CARL B. SCHRECK, AND
MICHAEL L. KENT

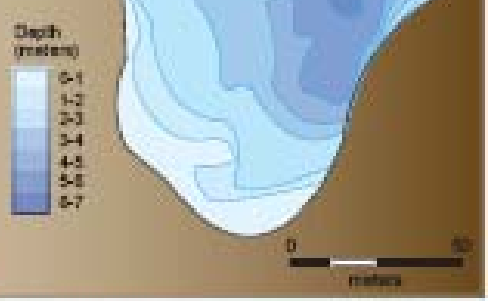
Hageman, K. I. et al. 2006. Atmospheric Deposition of Current-U in Snow at National Parks in the Western United States. ES & T

Olympic National Park: *Site Characteristics*

OLYM

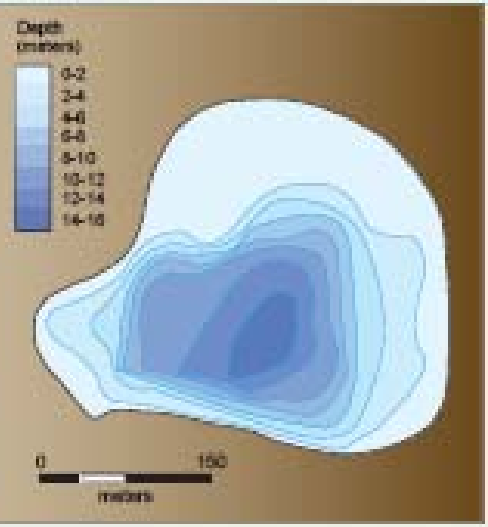
PJ Lake

Location: 47.95N 123.42W
Elevation: 1383.8 m
Maximum Depth: 6.4 m
Surface Area: 0.8 ha
Watershed Area: 56.2 ha



Hoh Lake

Location: 47.90N 123.79W
Elevation: 1379.2 m
Maximum Depth: 14.9 m
Surface Area: 7.7 ha
Watershed Area: 43.9 ha

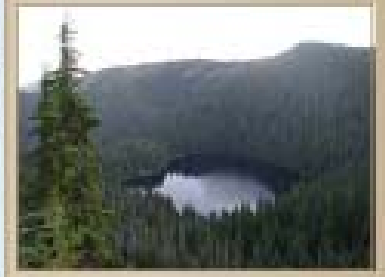


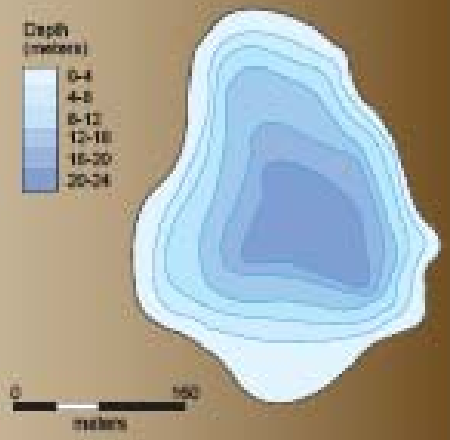
MORA

Mount Rainier National Park: *Site Characteristics*

Golden Lake

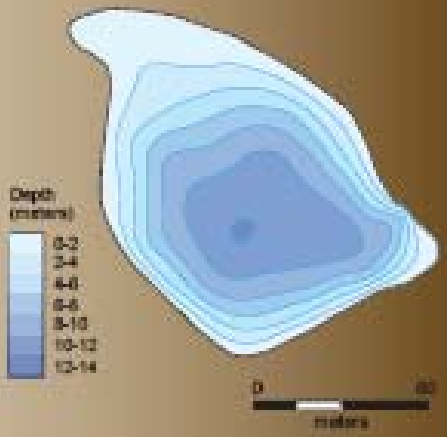
Location: 46.69N 121.90W
Elevation: 1368.6 m
Maximum Depth: 23.9 m
Surface Area: 6.6 ha
Watershed Area: 106.1 ha





LP19

Location: 46.62N 121.89W
Elevation: 1371.6 m
Maximum Depth: 12.1 m
Surface Area: 1.8 ha
Watershed Area: 44.9 ha



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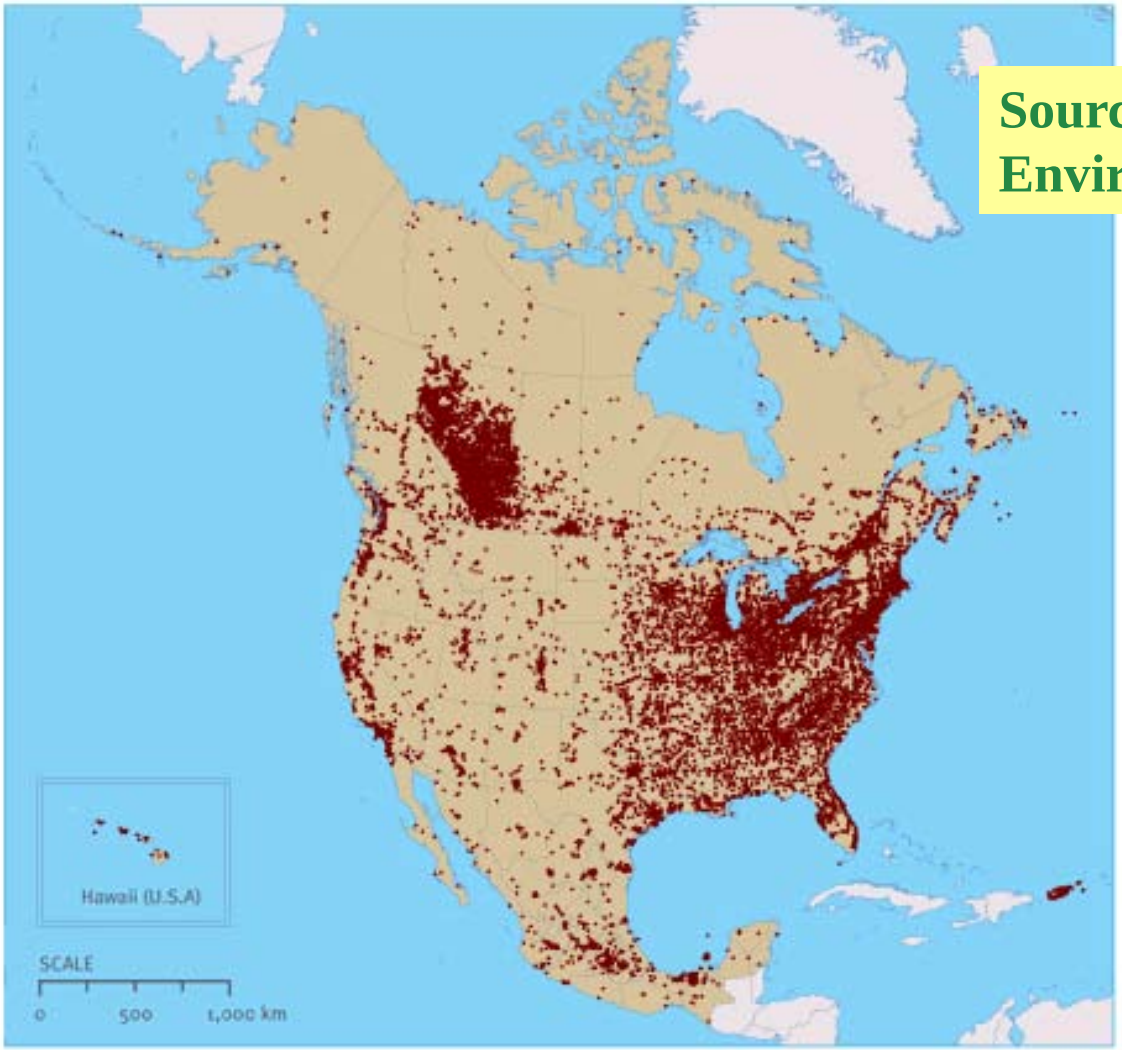
Industrial pollutants, 2004



Source: North American Environmental Atlas

Description

This map shows the locations of almost 34,000 industrial facilities in North America that reported on releases or transfers of pollutants in 2004. Data for this map was assembled from each of the North American country's Pollutant Release and Transfer Registers (PRTRs): the National Pollutant Release Inventory (NPRI) in Canada, the Registro de Emisiones y Transferencias de Contaminantes (RETC) in Mexico, and the Toxics Release Inventory (TRI) in the United States.

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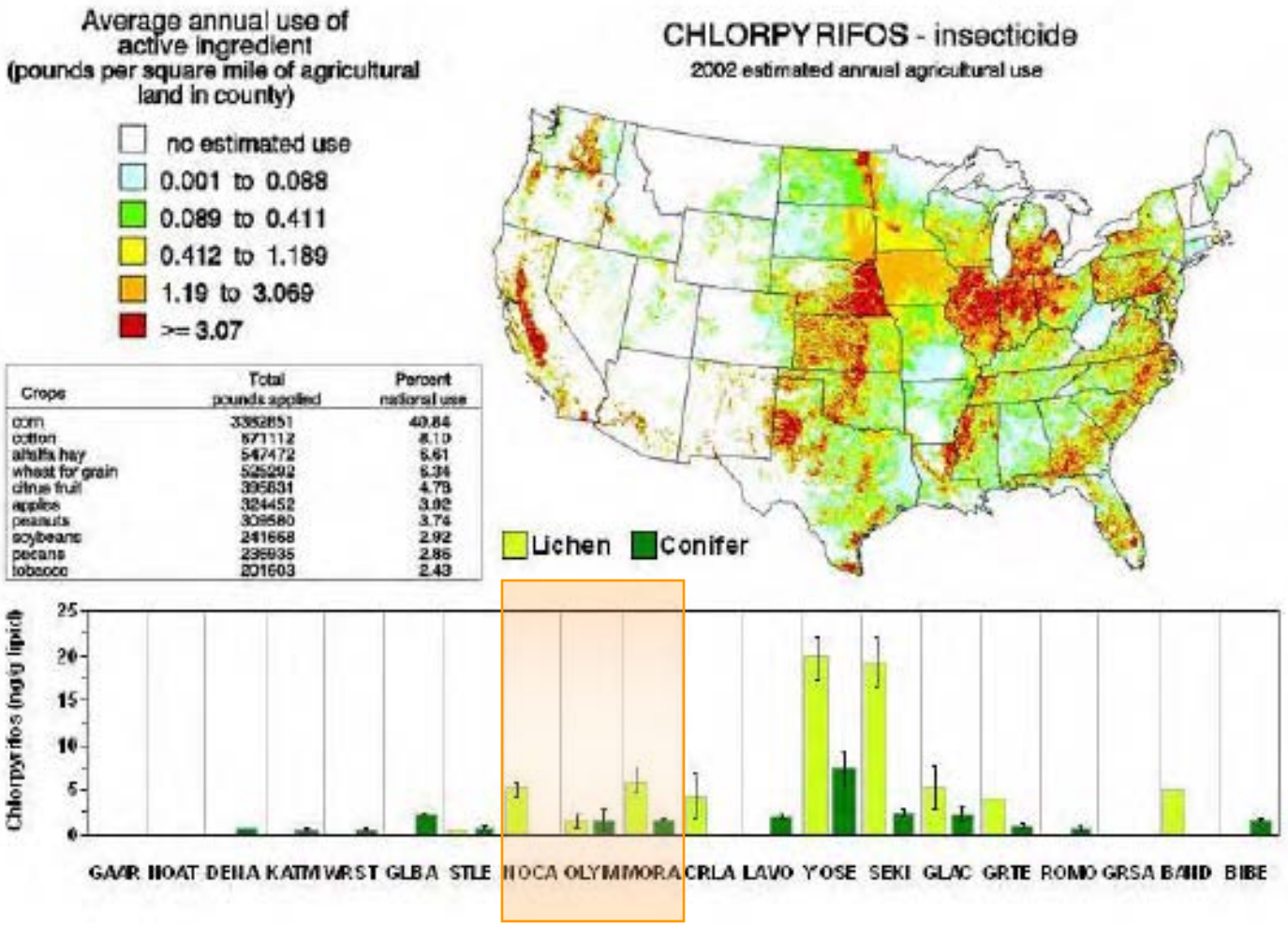

Figure 4-14. Uses and Estimated Application Intensity in 2002 of the Current-Use Insecticide Chlorpyrifos in the Conterminous 48 States vs. Mean Concentration in Vegetation (ng chlorpyrifos/g lipid conifer needles or lichens) from WACAP Parks. Chlorpyrifos were detected in vegetation in all parks except NOAT and GAAR, but highest concentrations were observed in SEKI and YOSE, close to the San Joaquin Valley in California, a particularly high use area. Error bars indicate one standard error.

Source of chlorpyrifos data:
http://ca.water.usgs.gov/pnsp/pesticide_use_maps/show_map.php?year=02&map=m6009.

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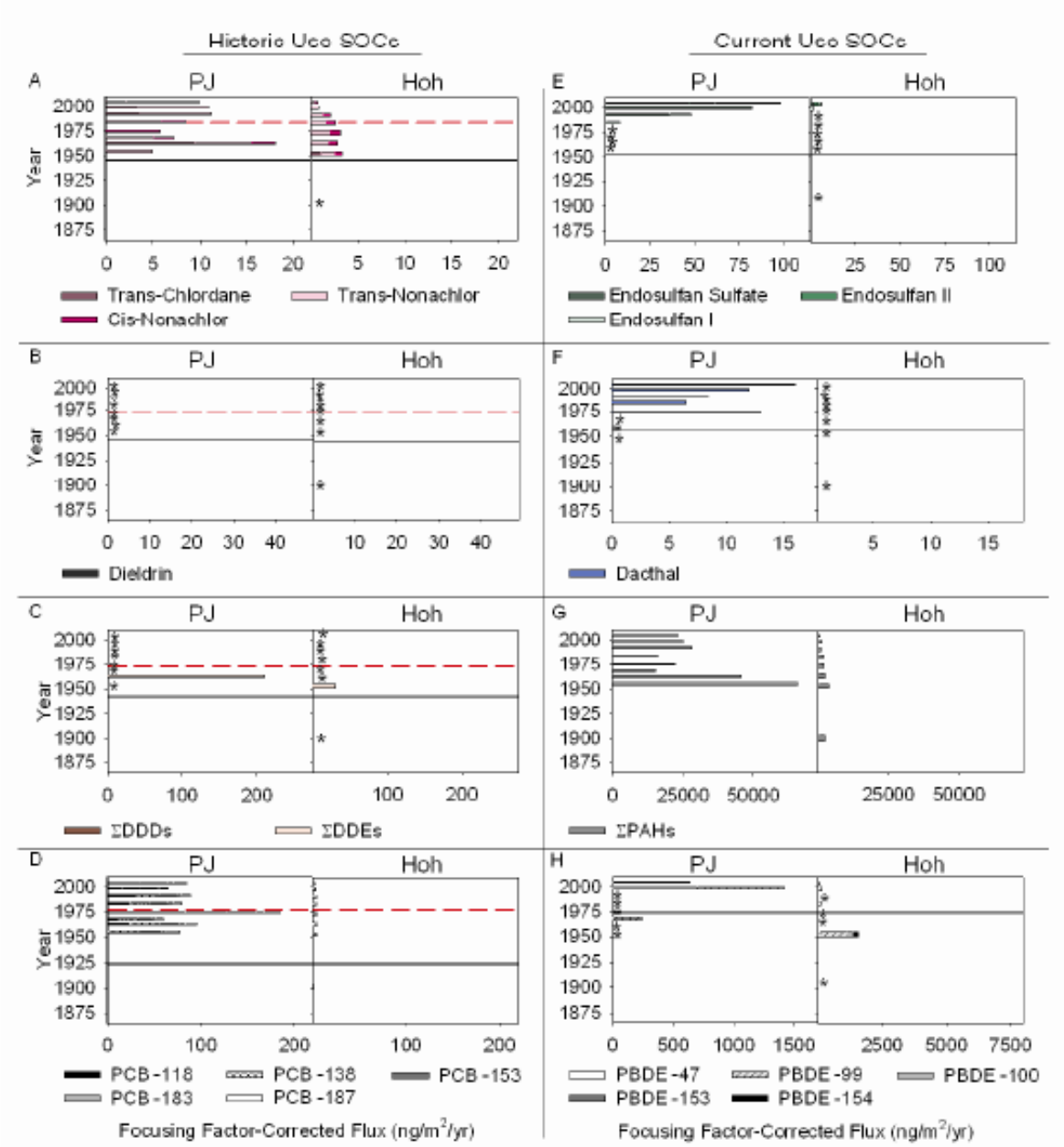

Figure 4-26. Focusing Factor-Corrected Flux (ng/m²/yr) Profiles of Current- and Historic-Use SOCs in PJ Lake and Hoh Lake Sediment Cores at OLYM. Solid lines (——) indicate US registered use dates, dashed lines (– – –) indicate US restriction dates, and asterisks (*)indicate below method detection limit.

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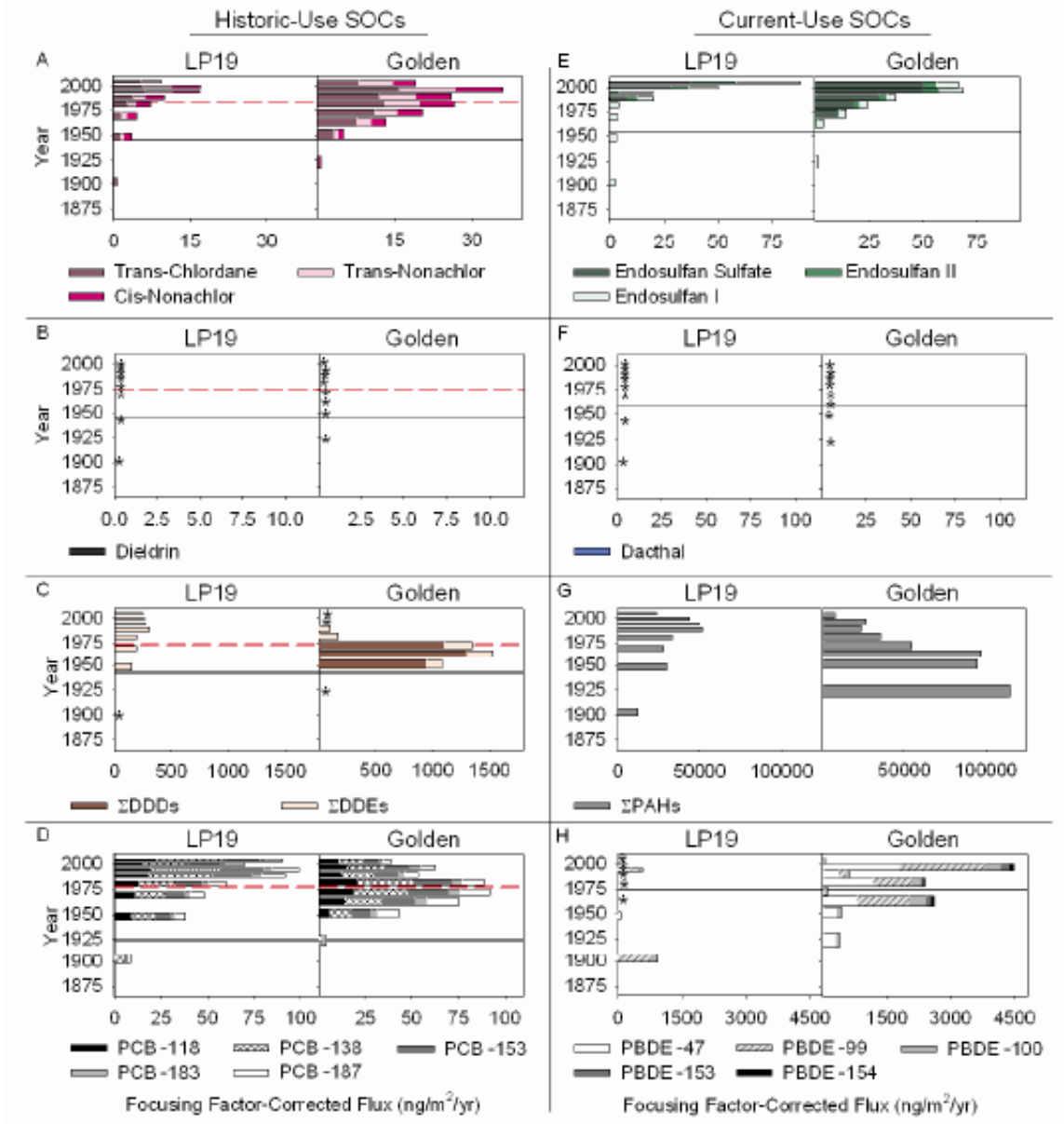
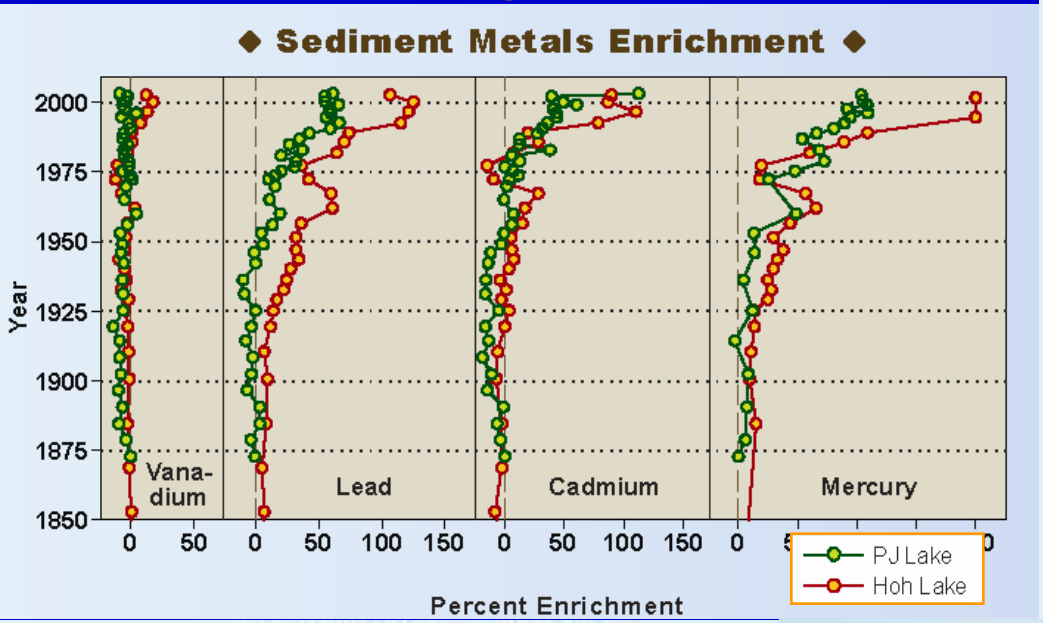
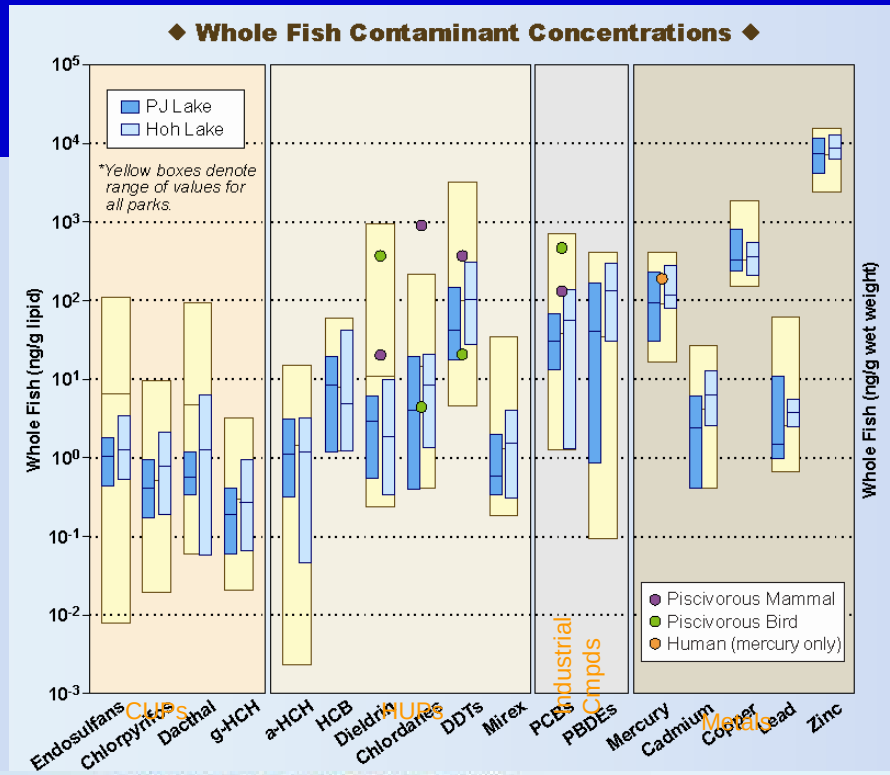
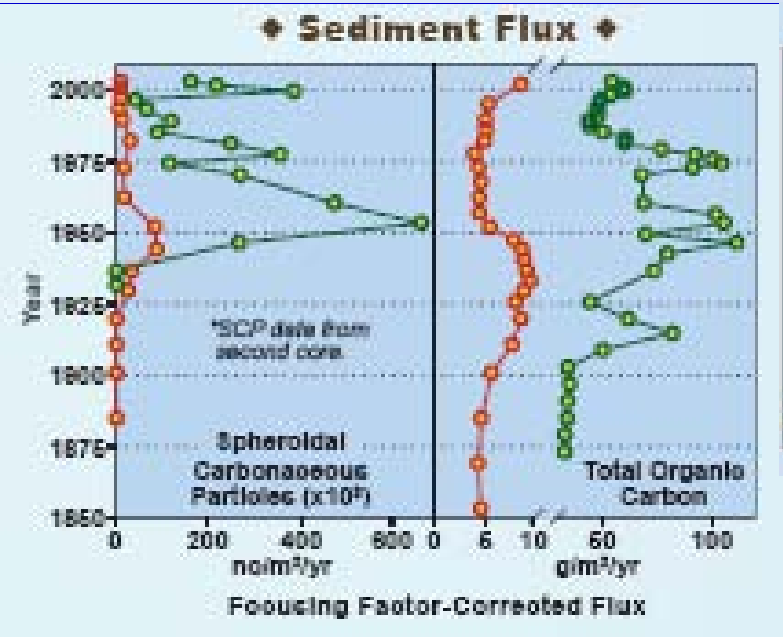


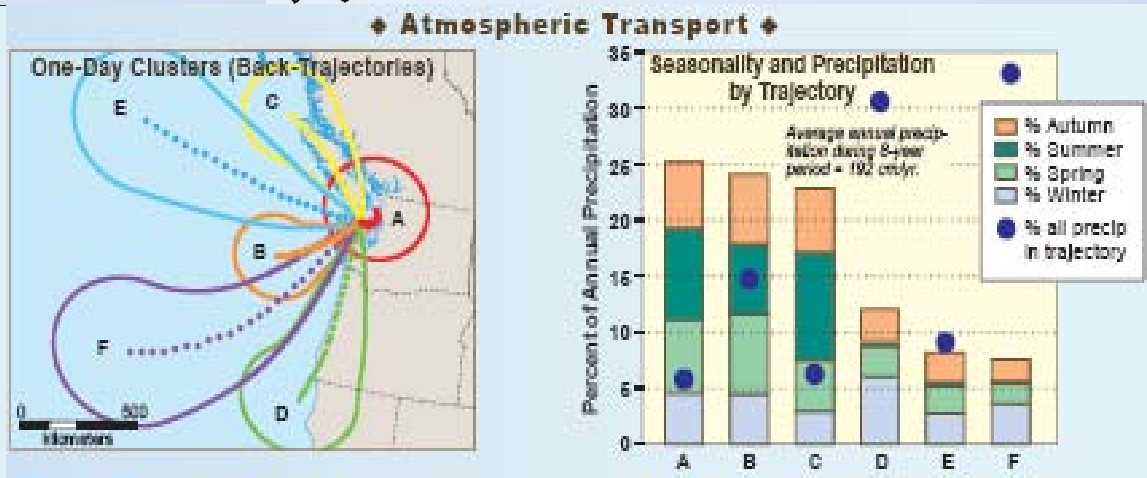
Figure 4-27. Focusing Factor-Corrected Flux (ng/m^2/yr) Profiles of Current- and Historic-Use SOCs in LP19 and Golden Lake Sediment Cores at MORA. Solid lines (——) indicate US registered use dates, dashed lines (– – –) indicate US restriction dates, and asterisks (*)indicate below method detection limit.

Olympic National Park: Park Summary

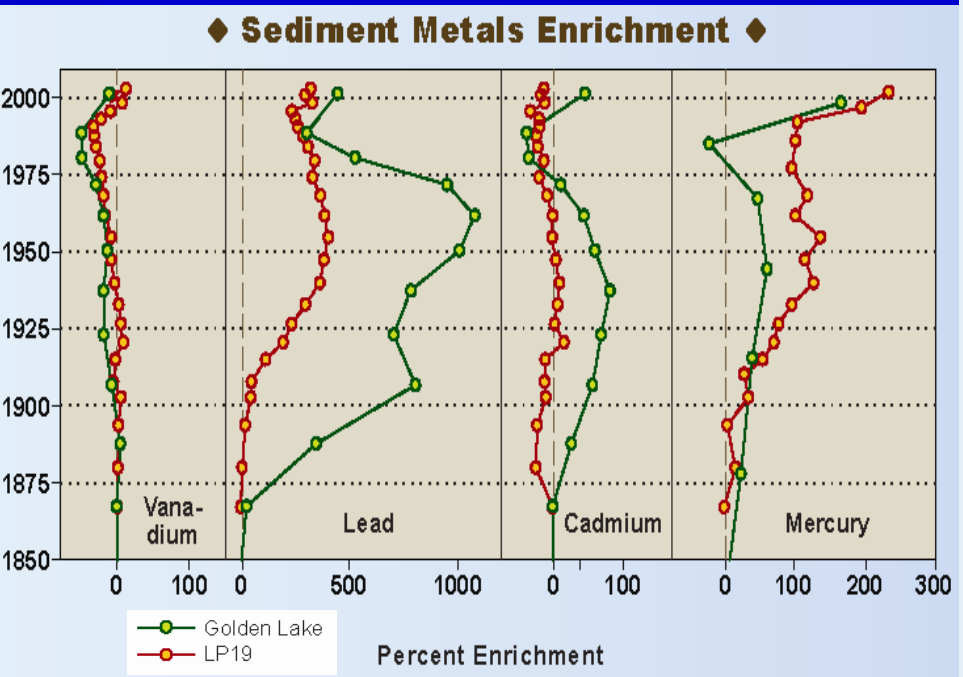


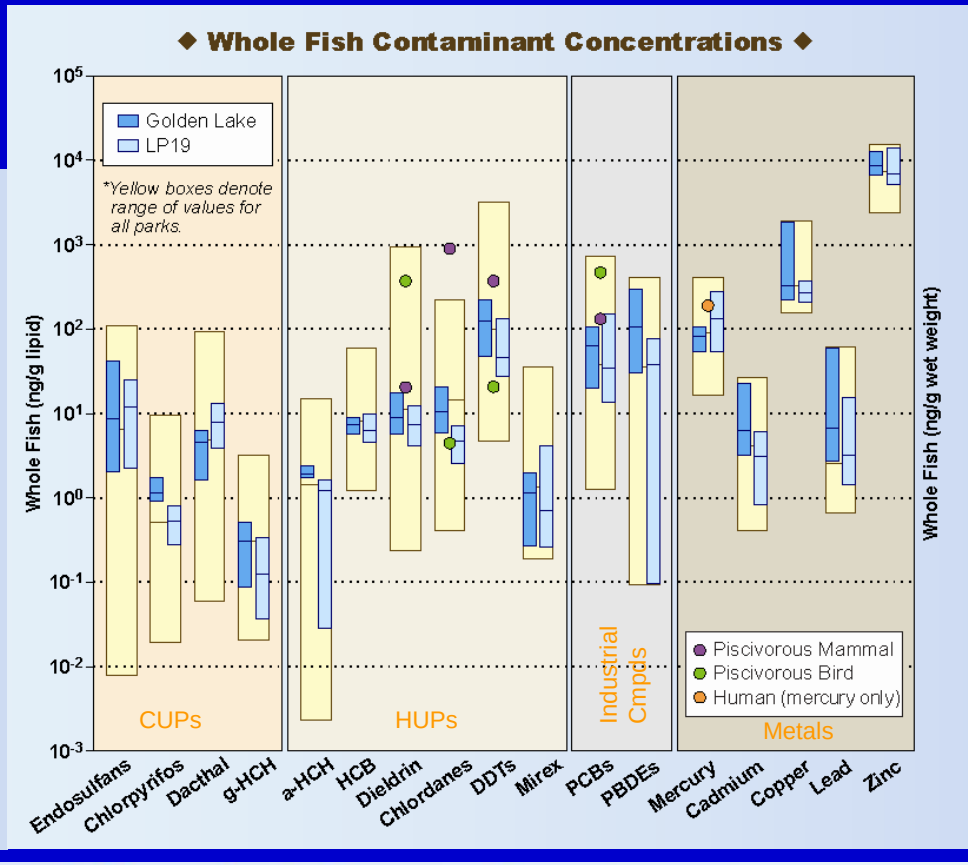


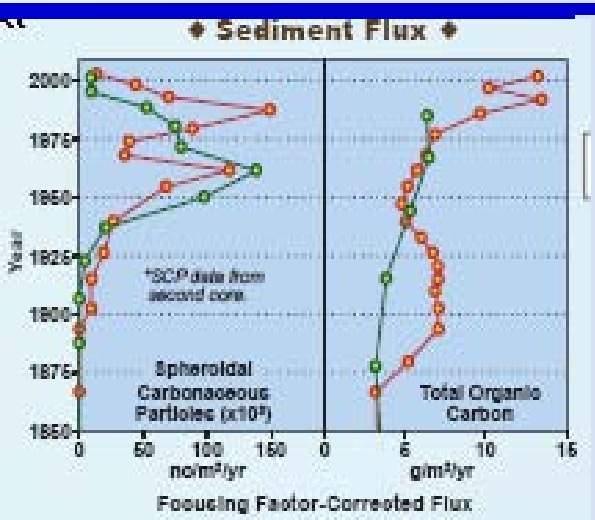


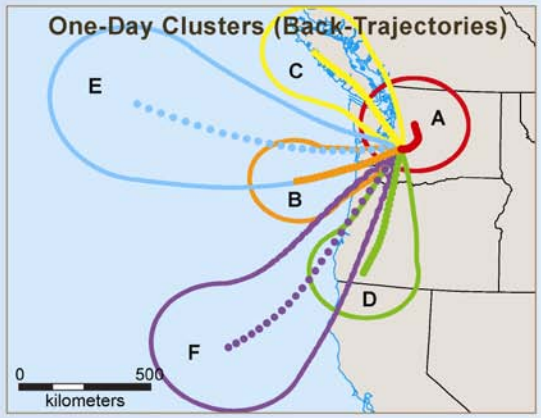


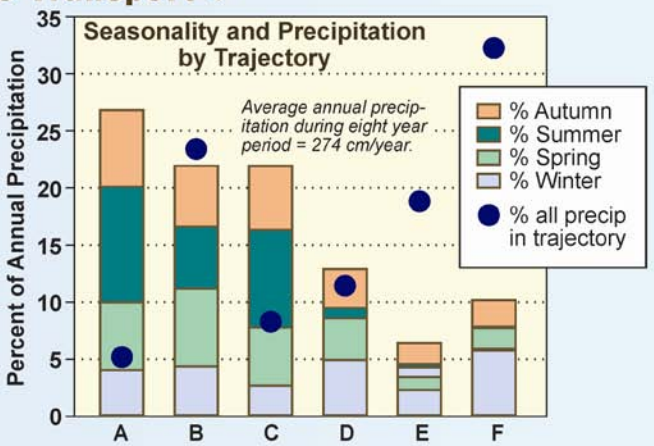
Mt. Rainier National Park: Park Summary











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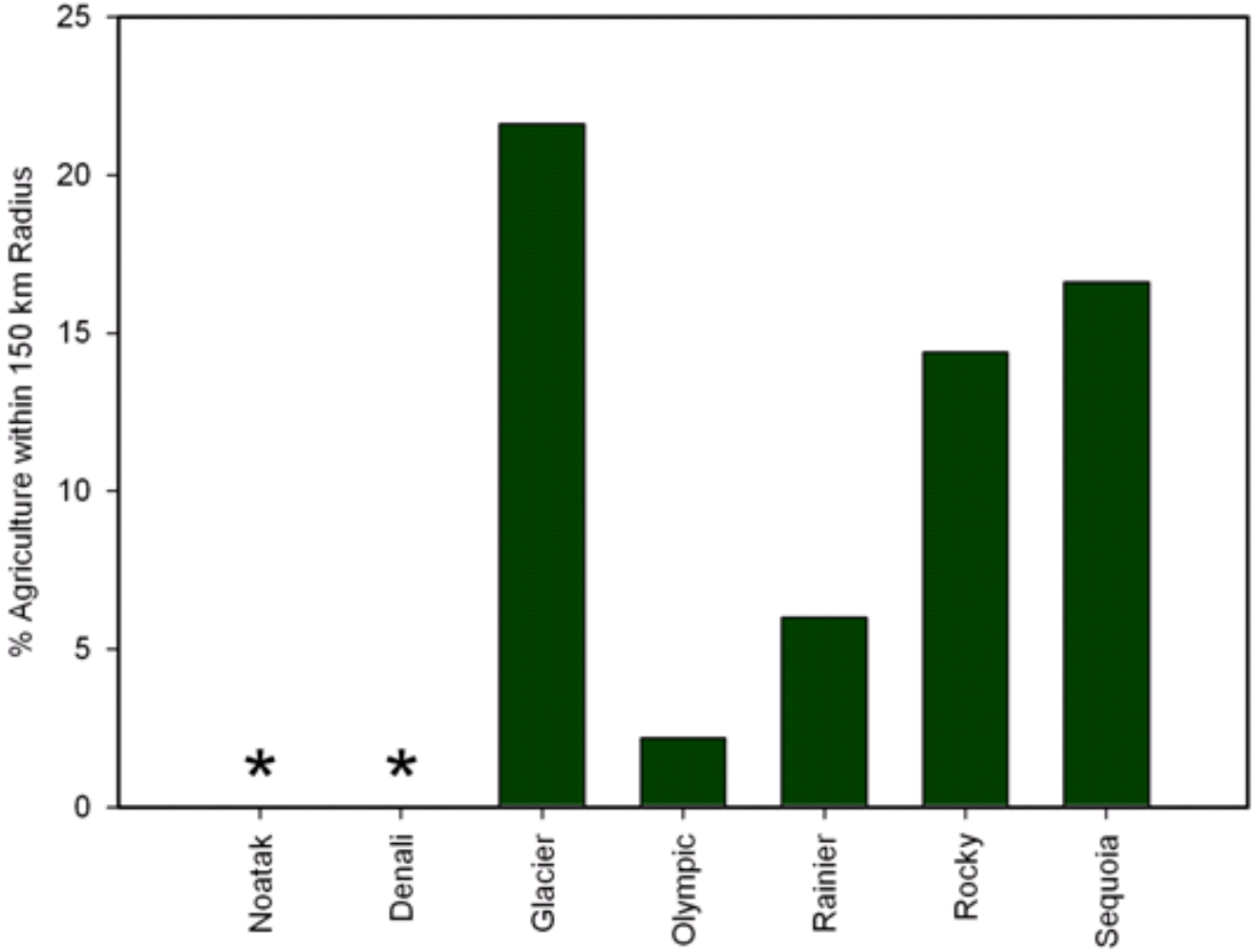

Figure 6: Percent of agricultural land within 150 km of the primary WACAP parks. Alaskan parks have no surrounding agriculture.

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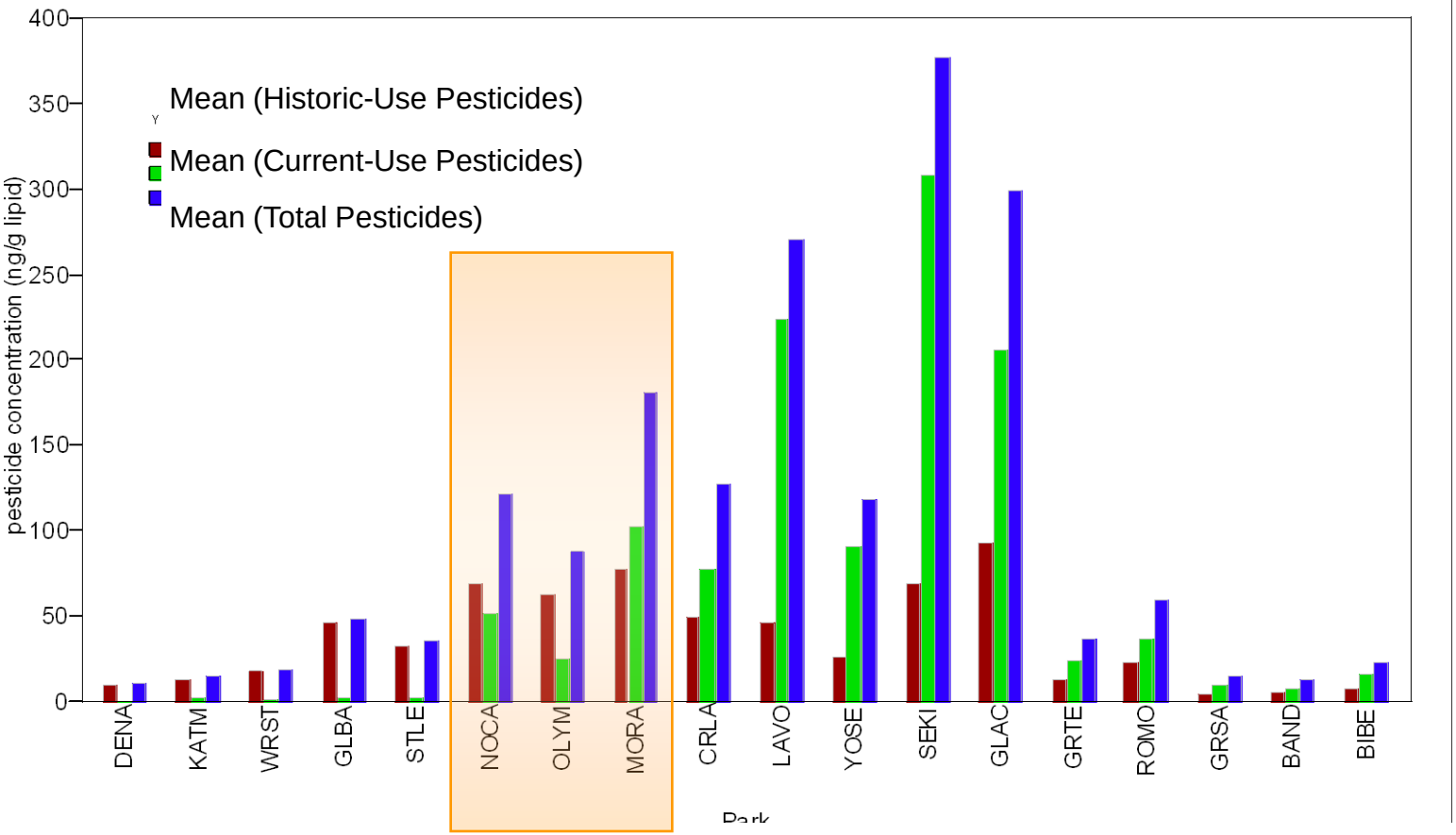
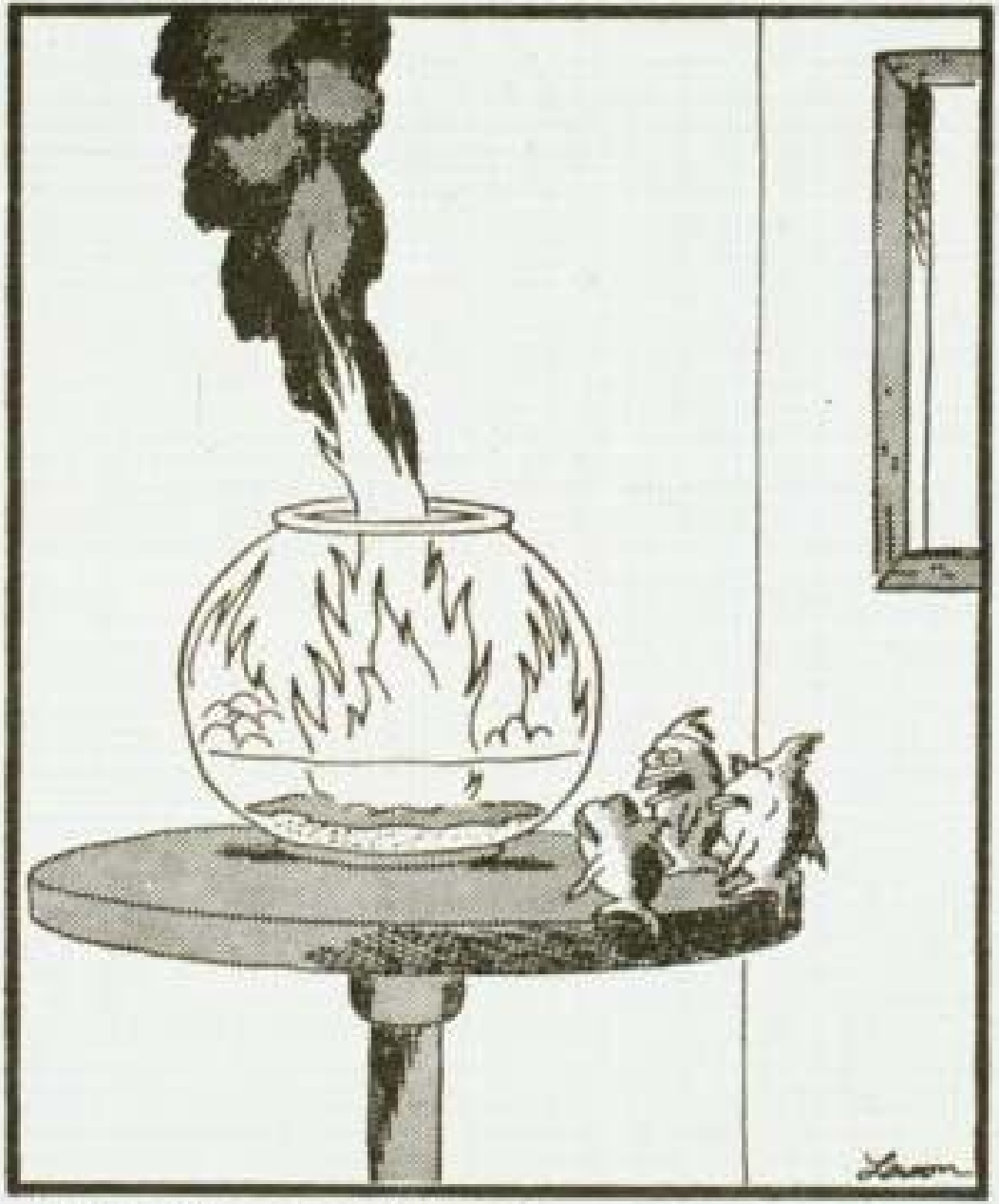


Figure 4-31. Mean Concentrations of Historic-Use (HCB, HCHs, Chlordanes, DDT, Dieldrin) and Current-Use (Trifluralin, Triallate, Chlorpyrifos, Dacthal, Endosulfans) Pesticides in Two-Year-Old Conifer Needles from WACAP Parks. Parks are ordered, left to right, from north to south along the Pacific Coast (DENA → SEKI), and from north to south in the Rocky Mountains (GLAC → BIBE). Current-use pesticides were not detected often in Alaska parks, comprised about one-third to one-half the total pesticide concentrations in northern Washington, and most of the pesticide burden elsewhere. Conifer needles were not sampled in NOAT and GAAR. Total pesticide burdens (current-use + historic-use) were highest in national parks of Washington, Oregon, California, and Montana.

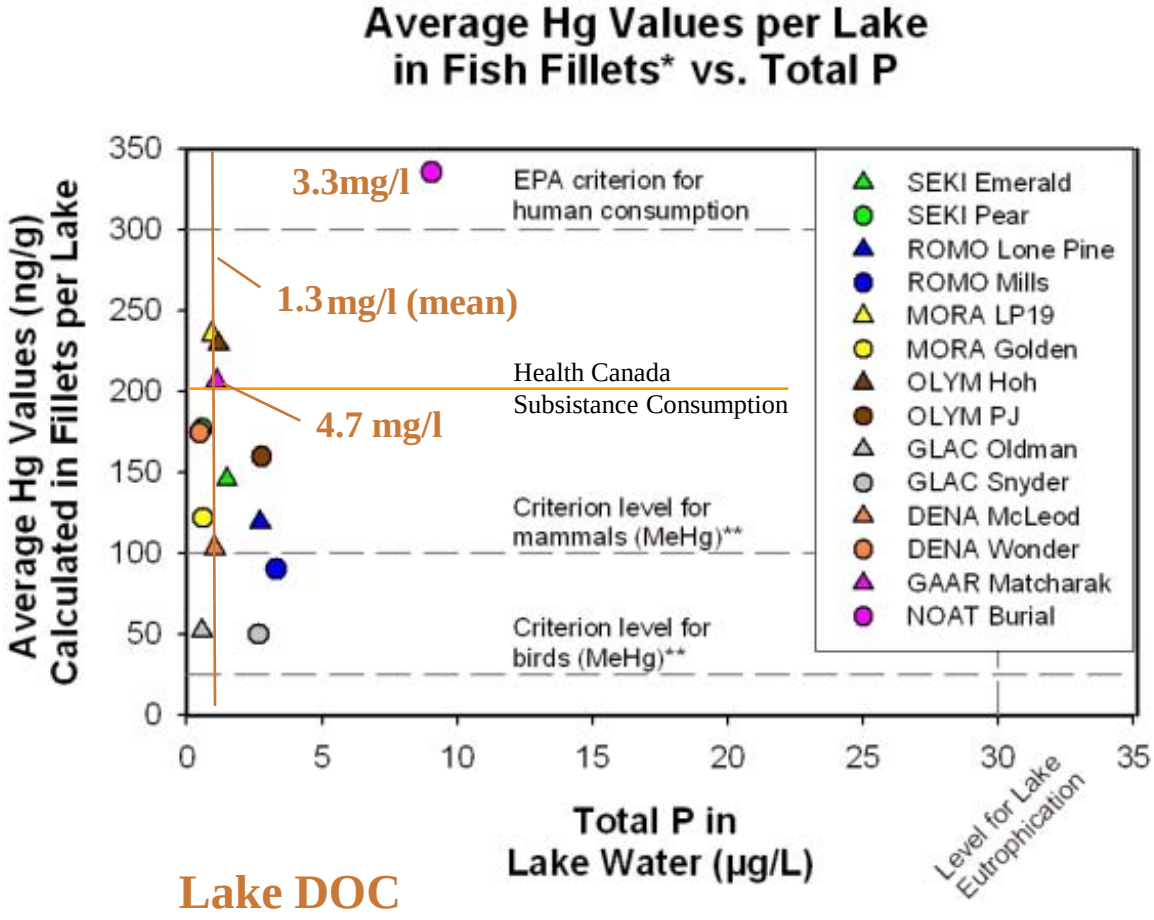
Finis

WACAP WEB SITE:
http://www2.nature.nps.gov/air/studies/air_toxics/wacap.cfm



"Well, thank God we all made it out in time. ...'Course, now we're equally screwed."

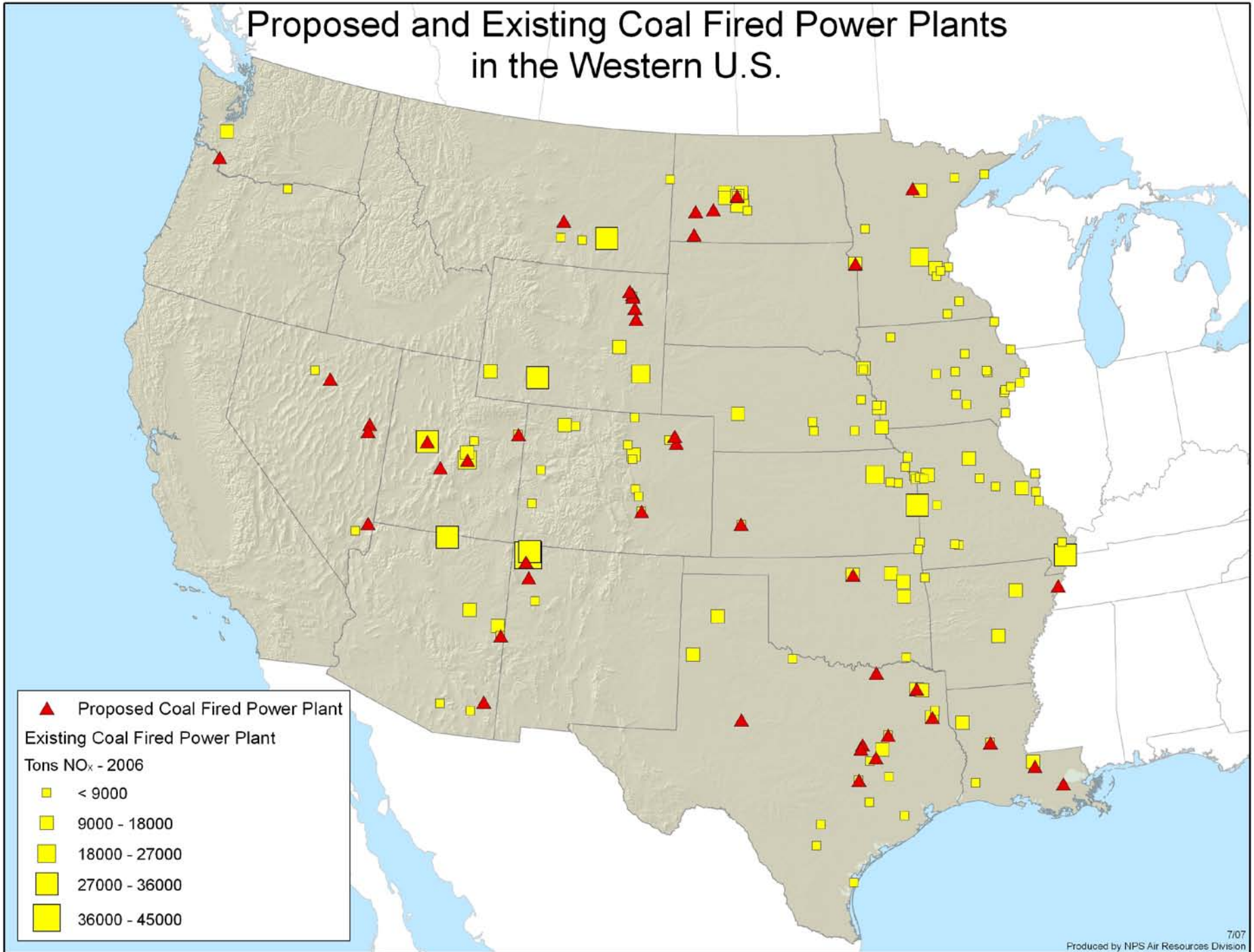
You can run,
But you can't hide



* Fillet concentrations calculated from whole fish Hg concentrations with method from Peterson *et al.* (2005), Arch Environ. Contam. Toxicol. 48:99-107

**MeHg limits taken from Yeardley et al., 1998 Environ. Toxicol. Chem. 17:1875-1884

Proposed and Existing Coal Fired Power Plants in the Western U.S.



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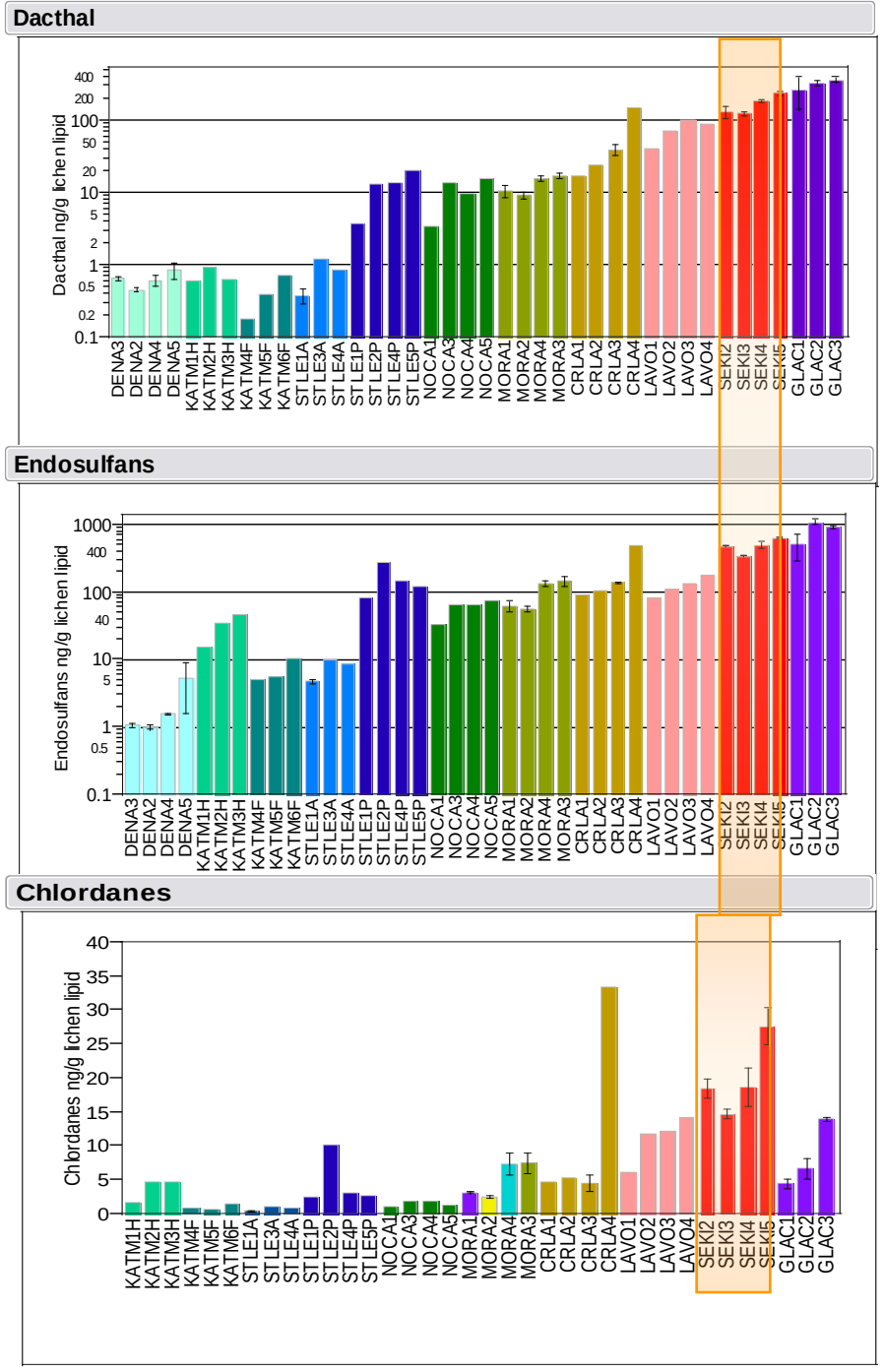

Lichens plotted by elevation within Parks

Figure 4-22. Elevational Gradients for Sum Dacthal, Sum Endosulfan, and Sum Chlordane Concentrations in Lichens. Within each park, sites are listed in order of increasing elevation. Codes H, F, A, and P refer to lichen species sampled (see Table 4-4). Bars show the standard error. Statistical analyses of elevational gradients are reported in Tables 4-3 and 4-4. Additional graphic displays for other SOCs are given in Appendix 4A.10. See Chapter 3 for data selection criteria for elevational trends analyses.