Lake Champlain Steering Committee Meeting

Thursday June 6, 2019
[The Essex Resort, 70 Essex Way, Essex, Vermont 05452]

Draft Meeting Summary

Participants:
Steering Committee Members: Julie Moore (Chair, VT Agency of Natural Resources), Bob Stegemann (NYS Dept. Environmental Conservation), Nathalie Provost (Quebec Ministry of Environment and Climate Change), Mel Cote (EPA Region 1), Vicky Drew (NRCS-VT), Andrew Milliken (US Fish and Wildlife Service), Ryan Patch (VT Agency of Agriculture, Food and Markets), Craig Digiammarino (VT Agency of Transportation), Mark Naud (Vice-Chair, VT Citizen Advisory Committee), Breck Bowden (Lake Champlain Sea Grant), Pierre Leduc (Quebec Citizen Advisory Committee), Neil Kamman (Chair, Technical Advisory Committee), Buzz Hoerr (Chair, Education and Outreach Advisory Committee), Vic Putman (Chair, NY Citizen Advisory Committee), Laura Treischmann (VT Agency of Commerce and Community Development) Phone: Mario Paula (EPA Region 2), Brian Steinmuller (NYS Dept. Agriculture and Markets), Dennis Deweese (NRCS-NY), Jennifer Bechtel, (NYS Empire State Development)

Staff: MaryJo Feuerbach (EPA R1), Fred Dunlap (NYS DEC/LCBP NY Coordinator), Koon Tang (NYS DEC), Pete Laflamme (VT DEC), Bethany Sargent (VT DEC/LCBP VT Coordinator), Jordan Geller (VT DEC), Stefanos Bitzakidis (Quebec Ministry of Environment and Climate Change), Christina Stringer (NEIWPCC). LCBP Staff: Eric Howe, Meg Modley Gilbertson, Colleen Hickey, Jim Brangan, Ryan Mitchell, Elizabeth Lee, Ellen Kujawa, Lauren Jenness. Phone: Bryan Dore (EPA R1).

Guests: Tom Berry (Sen. Leahy), Thea Wurtzburg (Cong. Welch)

10:00 Meeting Begins *Julie Moore, Chair*

- Welcome and Introductions
- Draft Meeting Agenda review
- *ACTION ITEM:* April 2019 Steering Committee meeting minutes approval
- Motion By: Bob Stegemann
- Second by: Buzz Hoerr
- Discussion on the motion: Andrew commented CVNHP funding and the impacts of NEIWPCC indirect rate on available funds for this limited pool of funding.
- Vote: all in favor.
- Abstentions: none.

10:05 Public Comments

10:10 Director's Report – *Eric Howe, LCBP*

Welcome to Christina Stringer, representing NEIWPCC today. Members may recall that Jane Ceraso was here with Susan Sullivan for the April Steering Committee; Jane is no longer with NEIWPCC which is why Christina is here today. Christina worked with Jane in the Water Resource Protection Division within the NEIWPCC organizational structure, which is where LCBP is housed. Susan Sullivan sends her regards.

Jim coordinated a very successful planning workshop with grant recipients from the FY19 CVNHP budget and other partners who will be working on recognition of the centennial of the 19th amendment next year. The workshop was held on May 21 and hosted at the Lake Champlain Maritime Museum. Participants had opportunities to describe their new projects and identify potential opportunities to collaborate amongst each other, and tweak their workplans before they submit them to Jim later this summer. Feedback from this workshop was extremely positive, and I am considering similar workshops for some of our other grant programs.

The International Joint Commission projects – the flood mitigation reference and the water quality reference – continue to move forward. The next Technical Workgroup meeting for the flood study will be in Quebec next week, in which they'll be tweaking their workplan for the remaining two years of this study. They are now at the point where study managers are drafting mitigation options to take on the road later this fall and next winter. The water quality reference, focusing on Missisquoi Bay, is also moving forward, albeit with a 3-month extension. Pierre Leduc can share more about this in his updates later today. We will be reviewing draft management recommendations with the IJC's Champlain Science Advisory Group next week. We will have presentations from the IJC on both projects at the September Steering Committee meeting.

The Boat Launch Stewards (14) and Education and Outreach Stewards (2) are running full speed ahead now. Contracts for most of the funds awarded in the FY18 budget are now out and those projects are moving forward for the upcoming field season.

Meg has been working with the NEANS and the USACE on a hydrilla management effort in the Connecticut River. Survey protocols have been developed to follow throughout the River. Genetics analyses are turning out to be different than previous analyses, which may pose management problems. Hydrilla is currently in NY, MA, and CT. This species has not been found in ME, NH or NY.

Tom Berry pointed out that Jane Ceraso has been working on LCBP projects with NEIWPCC for several years. Tom recommended the Steering Committee send Jane a note to thank her for her hard work at NEIWPCC and for the LCBP. Eric will work on this with Julie Moore on behalf of the Steering Committee.

10:15 LCBP Budget review and FY20 priorities – *Eric Howe, LCBP*

The Steering Committee members should have received a copy of the final FFY19 LCBP and CVNHP budget that was approved during the April meeting. Please take some time to review the budget – it will hopefully align with members' expectations coming out of the April meeting. LCBP and NEIWPCC staff are working on developing the agreements with the EPA, GLFC, and NPS to support those tasks identified in the FY19 budget.

Jim reviewed the HAPAC budget development process. The Request for Pre-Proposals process worked very well for the Heritage program in FY19 and HAPAC will be following this process again for FY20. Out of 25 full proposals that were considered, 19 will be funded with FY19 funds. Prohibition will be part of the theme for the FY20 grants process, as will the other priorities that have been included in the current opportunities, such as internships and collections grants, as well as special projects.

Matt, Ryan and Eric met with representatives from NYS DEC and VT DEC a few weeks ago to review their initial priorities for consideration in the FY20 budget. The outcome of that conversation is in front of you for discussion today. TAC also met in May and again yesterday to discuss priorities for the FY20 budget. This handout is also in front of you today for consideration.

Matt Vaughan and Neil Kamman reviewed the list of TAC priorities for FY20. The TAC developed this list after conversations over the May and June meetings, and wrapped it up yesterday afternoon. Andrew suggested that we replace the word "research" with "projects" in Bullet 2. Andrew also suggest that 2a be modified to "Native species and their habitat". Tom Berry noted that the TAC focus is typically research, then implementation. Is it the role for the TAC to identify implementation priorities? If not, how are these implementation priorities built into the LCBP budget process? Neil responded that the TAC is mindful of this. The TAC discussion yesterday went through research priorities, knowing that the States and others on the Steering Committee will be proposing implementation projects. Matt added that LCBP currently has two large competitive grant processes that serve as opportunities for implementation grants within the LCBP budget. Bob Stegemann added that the Steering Committee has been trying to find the right dynamic between research and implementation. This conversation is very healthy to have, because we can support many implementation grants but without the research we might not be awarding the right grants. Pierre added that any implementation project that is supported by the Steering Committee should have a strong learning or research component and if it works, then the States or Province can then know that it is a good program and they can move the program forward on their own. Koon added that NYS DEC and VT DEC have been coordinating together for the past few years to make sure that priorities proposed by the two states are not duplicative in effort and optimize the available resources. MaryJo asked if TAC had any specific thoughts regarding some of the broader priorities, such as Bullet 2. Neil responded that we may reduce the need for other infrastructure if we can support conservation projects that can do this more expensive work for us. MaryJo also pointed out that the Steering Committee chose to not support a microplastics project in the last budget; does Bullet 4 help us get there? Neil suggested that if we are going to include Bullet 4 as a priority in the RFP, if there is a competitive proposal addressing this priority then the Steering Committee should be prepared to tune it up and support it. Neil clarified that Bullet 5 is from work happening at VT EPSCoR that is demonstrating there is a need to learn more about winter dynamics in the lake. Breck pointed out that guidance in the RFPP is a balancing act; do we ask the very specific questions, or do we leave the door open enough to allow for projects that the TAC didn't think of. There was some conversation around assessment of outcomes of projects that were supported in previous budget years, and connecting priorities with awards from previous years, perhaps to help build off the successful outcomes and information learned from previous grants. The E&O committee also has had this conversation, regarding how to measure the outcomes of their projects.

Neil described the need for consideration for support to include automated monitoring in the LTMP. This would include instrumentation of monitoring sites that allow for higher resolution data collection that would inform management decisions. MaryJo asked if this automated monitoring concept might be included in the International Joint Commission monitoring work. This concept has been a part of that discussion to-date.

Koon clarified that the first three concepts described in the State priorities document are tasks that would be directed to the States to complete, as specific line items in the budget.

Mario asked about costs for Ag NPS Cost Share programs. If the State wants to award $1,000,000 into the Basin, LCBP would need to provide $200,000. Vicky encouraged LCBP to require expenditure of other federal dollars before LCBP funds are used to do this same work. Tom Berry also supported this – EQIP is the largest funding source for agricultural projects in the Basin. Brian Steinmuller added that these efforts are coordinated whenever possible. There are challenges to coordinating State and Federal funding within NY.

Regarding the forest roads concept, Bob added that there needs to be a solution that the landowners can deal with economically. We do not want to incentivize change out of the forested land use into something else.

Vicky asked the Steering Committee to support proposed RFP priority #3, to look at research into management practices that address soluble phosphorus.

Mel had an overarching question about the rationale for the first 3 items to be directly funded to the States rather than to be included in the competitive process. Koon responded that it would be more efficient for the States to manage these types of projects.

Andrew noted that RFP Priority # 4 syncs up nicely with one of the TAC priorities. #5 is a priority for the IJC flood study as well. Neil noted that there already are three active projects that address this priority. Finally, Andrew supported Tom's comment that we should make sure we are taking full advantage of other federal resources before LCBP dollars are used.

The group briefly reviewed the education and outreach-related priorities suggested by the States. There was a suggestion to clarify the target audience, and an appropriate scope.

Neil suggested that several of these State priorities can be synchronized with the TAC list quite easily. Pete suggested that there still is research that needs to be done regarding the flood storage project.

Mel registered a general concern regarding how much input the Steering Committee can have on the overall budget when there are so many line items that are installed in the budget now. Mel wants to make sure that this is the approach that the Steering Committee wishes to take. Eric will look at the proportion of the budget that is set aside for line items in the budget and prepare a presentation for the September meetings.

11:00 Overview of the Vessel Incident Discharge Act – *Meg Modley Gilbertson, LCBP*

Meg described the history of the VIDA and the opportunities for AIS created by the Act. Tom added that Champlain has the opportunity here to serve as a model for AIS work to the Great Lakes. Senator Leahy will look to the NY congressional delegation in the appropriations process, given their connection to the Great Lakes. Andrew commended Meg and Mario for their work on this to-date, and highlighted the opportunities that may come out of this authorization for the Lake Champlain basin.

11:15 Presentation: Where have we come from and where are we headed? Technical report on Lake Champlain tributary loading, 1990 – 2017 – *Matthew Vaughan, LCBP*

Tabled for a future meeting.

11:30 Legislative Updates

Tom Berry noted that Senator Leahy has his requests in to the Senate appropriations committee for FY20. The Farm Bill is in place. Tom added there had not been a budget agreement in place that includes FY20, so the bottom line for FY20 is currently unknown. The IJC now has it's full contingent of commissioners that have been appointed by President Trump.

Thea Wurzburg added that Congressman Welch has done the same in the House.

11:45 Brief Jurisdictional Updates *(NY, QC, VT, US Federal Partners)*

Julie reported that the VT General Assembly passed a significant piece of legislation this year to provide about ~$18 million in SFY20, and ~$20 million and more beyond. This legislation includes support for a regional service delivery model and quantification of phosphorus reduction from various delivery services.

Bob reported that NYS DEC opened a new AIS boat wash station at Exit 18 of I-89. NYS DEC has a new 5-year contract with AWI for AIS Steward work. Please see the written updates for additional details. Bob noted that there are new engineering planning grant opportunities that are open. An RFP is out for WWTF services. The previously LCBCP funded WWTF asset management project was very successful and many projects and programs are moving forward as an outcome of that project. Bob added that the flooding in the Great Lakes, Saint Lawrence River and in NY are the focus of a lot of attention right now. Outcomes of this will be new programs for flood resiliency, which will carry over to NY.

Nathalie Provost reported that Quebec is moving out of a big flood, so the Quebec government created a ministerial action group to help understand the needs of people who need support from large floods. Properties that have been flooded out in the past that are in the flood zone may need to be mitigated. Illegal dumping of contaminated soils has been addressed in stronger laws regarding movement of contaminated soils across Quebec. This bill was tabled until next month.

Mel Cote followed up on the reorganization that is moving forward at EPA Region 1. MaryJo added that EPA recently released information relating to cyanotoxins and their effects on public health. States should consider this information in consideration of public health and water quality standards.

Mario added that the reorganization in Region 2 was less disruptive than the process Region 1 has been going through. The FY19 allotment of funds to NYS DEC is moving forward.

Vicky Drew commented that the VT Agricultural Water Quality Partnership held a science week in early May, in which the group learned a lot around new science for agriculture and water quality. Vicky wants to use this information to ensure there is sound science behind all of the practices NRCS is supporting. The CIG grant opportunity is out Nationally and for Vermont now, due at the end of July. This is the last year of the Lake Champlain commitment from USDA in 2014. Vicky will be summarizing results from all of this work. There was a long backlog in engineering and other technical support services. Now that this has been addressed, NRCS programs are oversubscribed by $8 million. Vicky added that VT PBS will be airing a show called the "Faces of Agriculture".

Dennis DeWeese deferred to his written report.

Andrew Milliken reported that USFWS staff participated in a newly formed group facilitated by Matt Vaughan called the NY Dam Task Force. Work on the International Year of the Salmon (IYS) continues forward with LCBP and the CVNHP. A professional development course coordinated by the LCMM to bring interpreters from around the lake up to speed on history of salmon and salmon issues was very successful. An LCBP-funded project to TNC to work on the Boquet River is going forward in partnership with USFWS to identify salmon redds, and to identify high priority existing and potential habitat for Atlantic salmon. Please check out several website opportunities, including the LCBP page, to find out where events are happening this summer. The LCMM has a lot of resources around the IYS on their website as well.

Breck Bowden announced for Lake Champlain Sea Grant that the Watershed Alliance program that has been running in VT has now been expanded to NY, partially with LCBP support. There is a draft national strategy for aquaculture that is floating around. The freshwater Sea Grant programs would like to see more aquaculture work.

12:15 **LUNCH** *(Provided)*

1:00 **Advisory Committee Updates** CAC: QC, NY, VT; TAC, E&O, HAPAC

Pierre Leduc, Quebec CAC: Pierre highlighted a new program to help communities become more resilient to climate change. There is a new $5 million opportunity for a grant to apply BMPs and to study social and economic factors that help farmers accept and apply their practices. Pierre informed the group that Richard Lauzier passed away in April after a short fight with cancer. There is an effort to rename the Castor Brook after Richard. Pierre asked about the agreement with QC and VT. The process is moving forward, with a goal of approving the MOU by the end of the year.

Mark Naud, VT CAC: the CAC is nearly back to full capacity, with one vacancy left to be appointed. The CAC will have a retreat next month to discuss activities for the upcoming year

Neil Kamman, TAC – TAC reviewed that Stone found significant reductions in TP and DP concentration, but not in loads on a grassed waterway practice in Shelburne. The study was well executed, but ran into challenges with the landowner applying practices in the appropriate timeframe and locations. Neil pointed out that the McKenzie watershed monitoring study is nearing completion. Preliminary results suggest that these small tribs have remarkably high phosphorus concentrations. It was very difficult to monitor flow in these tributaries.

Buzz Hoerr, E&O Committee – the E&O Committee met on May 10 to discuss the outcome of the budget. The group was very happy with the way the budget process worked out in the FY19 process. Colleen highlighted the Healthy Soils program and signage on public transportation buses in the Chittenden County area. The two Education and Outreach stewards are out and about throughout the VT and NY watersheds. Ryan commented that the TMDL outreach tools project is getting underway. This will be developing

Jim Brangan, for HAPAC – Jim highlighted some of the International Year of the Salmon programs, including the interpreter training scheduled for next week. The LCMM's Lois McCLure will be running her annual voyage on Lake Champlain this summer to promote IYS. The annual CVNHP Heritage Summit will be in Quebec on October 7 to discuss Heritage programs for FY20. The NPS allocated close to $330,000 for the CVNHP in FY19. This information became available after the Steering Committee approved the budget in April. Jim and Eric Howe reviewed the prioritized list of projects the Steering Committee considered in April, and identified additional suitable projects to support with the additional $30,000 that had not been anticipated in April. Additional funds also will support development and fabrication of traveling exhibits for the centennial of the women's suffrage movement. HAPAC will meet later this summer to discuss criteria for FY20 RFP. There is a new commemorative passport available to celebrate IYS.

1:15 Presentations and discussion:

NRCS-VT Strategic Watershed Approach, *Vicky Drew, VT State Conservationist*

Vicky Drew presented on the new NRCS Strategic Watershed approach. This was initiated to further water quality improvement for strategic watersheds, and has been guided by a steering committee to focus on several high-priority HUC-12 watersheds. Phase 1 of this project (2015-present) focused on stakeholder engagement and feedback, resulting in several key strategies and a 5-year phosphorus reduction plan for each priority watershed. NRCS set aside 50% of the total water quality funds for Lake Champlain to support these priority watershed efforts; to date since FY16, NRCS has spent over $6m in these six watersheds, and an additional $335,500 to partner organizations to provide technical assistance. Phase 2 of this project includes a smaller planning group proposing next steps of watershed planning and implementation goals. Much of this implementation work is funded by NRCS, but can also be funded by VAAFM, UVM Extension, or by the farmers themselves. Overall, Vicky believes that this process has been successful. The keys to success have included cross-agency collaboration, the combination of science and demonstration efforts visible to farmers, farmer involvement, and focused funding over a longer timescale. Challenges included a lack of dedicated staff resources, difficulty accounting for phosphorus reductions achieved, and a lack of farmer participation in some watersheds.

- Buzz Hoerr wondered about the current economic challenges for farmers; how do these issues affect the program's success? Vicky noted that these issues present major difficulty for staff, who hear difficult stories of farm hardship. It can also present contracting issues when farmers are willing to implement projects but are ultimately unable to, due to financial hardship or other logistical challenges.
- Buzz Hoerr asked Neil Kamman whether there have been any notable changes in phosphorus concentrations as a result of these implementation projects; Neil answered that while it is not possible to answer that question yet, monitoring is ongoing with the goal of having the data to explore these issues.
- Breck Bowden asked where the remaining portion of the $45m appropriation for this work has been used; Vicky clarified that these funds have been used for implementation work elsewhere in the Lake Champlain watershed.
- MaryJo Feuerbach asked what characteristics correspond to better farmer participation. Vicky answered that areas that already have active farmer groups tend to have far better participation in this type of implementation initiative than areas with no active farmer groups.
- Pierre Leduc wondered how long a timescale is necessary to ensure the success of this type of project, as similar projects are close to being implemented in Quebec. Vicky noted that a five-year timeline was a reasonable start, but a longer timeline would probably help to increase farmer participation.

Water quality, Payment for Ecosystem Services, and the future of farming in Vermont, *Dr. Courtney Hammond Wagner and students from the GUND Institute for Environment, University of Vermont*

- Dr. Courtney Hammond Wagner and graduate students presented their recent research on a possible payment for ecosystem services program in Vermont. The proposed program is based on a series of interviews with stakeholders in the watershed, including watershed professionals, academics, and farmers. The hopeful outcomes of this project include phosphorus reduction, carbon sequestration, and preservation of Vermont's working landscape, and would rely on a performance-based payment system to farmers for phosphorus reduction. Significant work is necessary before a program like this one could be launched: determining collaborative partners, ensuring equity between stakeholders and conducting survey groups on public perception, and demonstrating the viability of this type of program in case studies. This research project resulted in a series of recommendations for implementing a payment for ecosystem services program.
- Buzz Hoerr asked whether it would be possible to calibrate the program's baseline to disincentivize poor performance by requiring farmers who are not achieving phosphorus reduction goals to pay impact fees. Pierre Leduc added that high impact environmental actions (like transitioning from hay to corn) should cost the farmer something.
- Vicky Drew asked how the $10 figures were developed, and how the payments for ecosystem services should relate to the cost of implementation. Courtney noted that the dollar amounts might be somewhat higher than reported, as these are drawn from existing literature. Eric Recchia added that he felt that most farmers will be willing to implement BMPs anyway, and even though a payment for phosphorus services may not fully pay for implementation, payment for other ecosystem services (flood retention, carbon sequestration) may cover this gap.
- Tom Berry asked how a payment for ecosystem services program differs from the work that NRCS already does. The group answered that many of the NRCS farmer payment programs are essentially payment of ecosystem programs. Vicky Drew added that most of NRCS's work is practice-based, rather than performance-based, but that the additionality issue needs to be resolved before a performance-based system could be implemented.
- Breck asked about the difference between modeled and measured performance. The scale is the farmstead and fields as the measurable unit. How would you propose to monitor the performance at this

scale? Adrian responded that one way would be to look at the HUC12 watersheds and anticipated outcomes at this level and the model the expected outcomes at the farm scale at this level.

- Neil asked about the starting point for this system, which assumes that the farm has achieved the farmgate mass balance. Would an incremental payment to get the farmer there be a good starting point? Adrian noted that more research is noted on this topic.
- Brian Steinmuller thanked the presenters for their hard work, and suggested that another issue of additionality might be what farmers need to give up (edges of field, riparian buffers, etc.) even if they have already achieved significant nutrient reduction. New York state has been incentivizing this sort of work through cost-share programs to promote long-term nutrient reduction strategies.
- Bob Stegemann noted that there might be market advantages to farmers participating in these type of payment for ecosystem services programs (similar to ingredients on restaurant menus being noted as organic or local), and suggested that this issue might be explored as part of the group's modeling effort. He also wondered whether a cap-and-trade system might be a viable possibility. Eric noted previous research that suggest a cap-and-trade system may not be possible, but the group plans to investigate the labeling possibility.
- Buzz Hoerr noted the importance of making sure that phosphorus never leaves the farm barn: extreme weather events will always result in increased phosphorus release into waterways. Courtney suggested that payments might be used convince farmers to remove cows from their farms, preventing manure from entering the farm at all.

Advancing Ecosystem Services in Vermont, *Ryan Patch, VT Agency of Agriculture, Food and Markets*

Ryan Patch presented on Vermont's healthy soils, regenerative agriculture, and ecosystem services work. The Ecosystem Services Working Group has been discussing the viability of a payment for ecosystem services system; this is an ongoing discussion in the state.

- Neil Kamman asked whether the model used for this work gives the farmer the tools to model BMP implementation on their property. Ryan answered that there is a web interface with this ability, and more work is ongoing to integrate the APEX modeling scheme.
- Adrian Wiegman asked how long the full payment for ecosystem services evaluation will take, and whether the data collected are being integrated into modeling the full watershed. Ryan noted that the answers to these questions are still unclear, which is why a pilot program is underway to investigate viability. He also noted that the VESP program relies on payment for practice, and payment for performance is a topic still to be explored.
- MaryJo Feuerbach asked whether farms need to achieve all requirements before being VESP-certified. Ryan answered that this is a topic of discussion, but currently 90% of a farm's fields need to be achieving all standards in order to receive VESP certification.
- Pierre Leduc wondered how much of the eligibility will be determined by modeling versus fieldwork. Ryan clarified that field visits will be required for a farm to enroll in the program, and that all data collected will be used to further calibrate the program's modeling efforts.
- Adrian Wiegman asked about the soil health test's origin. Ryan Patch noted that the VESP program has used the Cornell soil test so far.
- Breck Bowden asked whether the program title needs to be more farmer-oriented, or whether it will be applicable to other land use sectors as well. Ryan Patch answered that eventually, the program may be applicable to other land uses.
- Vicky Drew reminded the committee that a certification on milk bottles would be difficult to implement, as milk is co-mingled at dairy co-ops. Breck suggested that separate bottling might be useful.
- Alissa Whittier asked about the issue of farmer distrust in the state's regulatory process: how will the program address this problem? Ryan agreed that VAAFM is a regulatory agency and will remain so, and plans to facilitate the pilot and possibly launch of the VESP program but is open to not administering it in the longer term.

3:00 ADJOURN

Anticipated Meeting Outcomes:

1. *Approval of April 2019 Meeting Minutes*
2. *Approval of FY 20 priorities for Technical and Heritage RFPs*
3. *The Steering Committee will send Jane Ceraso a note of thanks for her work at NEIWPCC and for the LCBP.*
4. *Eric Howe will prepare a presentation for the September Steering Committee to describe budget outcomes from previous cycles, and the impact of increasing budget line items on the overall available budget.*

May 2019 Approved **FY2019 LCBP Budget**

Key Functions	Task Management	2019 TASK Request	TASK Cumulative Total	NPS Allocation	EPA Allocation	GLFC Allocation
VT Coordination	VERMONT	$ 161,427	$161,427	$0	$161,427	$0
NY Coordination	NEW YORK	$ 195,850	$357,277	$0	$195,850	$0
E&O Coordination	NEIWPCC	$ 180,000	$537,277	$0	$126,000	$54,000
Communication and Publications	NEIWPCC	$ 275,000	$812,277	$0	$206,250	$68,750
Technical Coordination	NEIWPCC	$ 245,000	$1,057,277	$0	$220,500	$24,500
ANS Coordination	NEIWPCC	$ 190,000	$1,247,277	$0	$171,000	$19,000
Administrative Assistance	NEIWPCC	$ 122,000	$1,369,277	$15,000	$109,800	$0
Program Direction	NEIWPCC	$ 160,000	$1,529,277	$18,000	$128,000	$16,000
Office Operations	NEIWPCC	$ 80,000	$1,609,277	$1,600	$38,400	$40,000
Resource Room	NEIWPCC	$ 185,000	$1,794,277	$0	$185,000	$0
NEI Administration	NEIWPCC	$ 195,000	$1,989,277	$8,000	$156,000	$29,250
CVNHP Coordination (includes NHA Direction)	NEIWPCC	$ 178,131	$2,167,408	$165,681	$0	$12,450
Gordon Center House rent	VERMONT	$ 18,500	$2,185,908	$0	$18,500	$0
Local Implementation Grants PP (300k) / AIS (200k) / OS (50k)	NEIWPCC	$ 550,000	$2,735,908	$0	$302,500	$247,500
Additional LCBP office space	NEIWPCC	$ 15,000	$2,750,908	$0	$15,000	$0
Funding Scenario FY2019	**EPA FY19 base**	**$4,395,000**	Category Sum	$208,281	$2,034,227	$511,450
	EPA-2016 TMDL	**$6,600,000**				
	NPS (CVNHP)	**$332,097**				
	GLFC	**$2,380,500**				
	Total	**$13,707,597**				

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Heritage Area Tasks	Task Management	2019 TASK Request	TASK Cumulative Total	NPS Allocation	EPA Allocation	GLFC Allocation
CVNHP Heritage: Youth & Student Engagement with the North Country Underground Railroad Historical Association	NEIWPCC - North Country Underground Railroad	$ 8,850	$2,759,758	*$8,850*	*$0*	*$0*
CVNHP Heritage: Because of Women Like Her…	NEIWPCC - League of Women Voters	$ 8,850	$2,768,608	*$8,850*	*$0*	*$0*
CVNHP Internship: Graduate Internship Program	NEIWPCC - Ticonderoga Historical Society	$ 5,900	$2,774,508	*$5,900*	*$0*	*$0*
CVNHP Internship: Internship in Nautical Archaeology and Historic Preservation: Steamboats of Lake Champlain	NEIWPCC - LCMM	$ 5,900	$2,780,408	*$0*	*$0*	*$5,900*
CVNHP Internship: Maritime Trades Internship	NEIWPCC - Fort Ticonderoga Assoc.	$ 5,900	$2,786,308	*$0*	*$0*	*$5,900*
CVNHP Internship: Franco-American History and Collections Internship	NEIWPCC - Samuel de Champlain History Center	$ 2,950	$2,789,258	*$0*	*$0*	*$2,950*
CVNHP Collections: Furthering Bixby Library's Collections Management Plan: NAGPRA Compliance and Repatriation	NEIWPCC - Bixby Library	$ 8,826	$2,798,084	*$8,826*	*$0*	*$0*
CVNHP Collections: Mount Independence Artifact Conservation Project	NEIWPCC - Mount Independence Coalition	$ 8,850	$2,806,934	*$0*	*$0*	*$8,850*
CVNHP Collections: Digitizing and Preserving Champlain's Photographic Heritage	NEIWPCC - Samuel de Champlain History Center	$ 4,130	$2,811,064	*$0*	*$0*	*$4,130*
CVNHP Collections: Pavilion Collections Project	NEIWPCC - Fort Ticonderoga Assoc.	$ 8,850	$2,819,914	*$0*	*$0*	*$8,850*
CVNHP Collections: Inventory Collections Initiative	NEIWPCC - Lake George Historical Assoc.	$ 8,850	$2,828,764	*$0*	*$0*	*$8,850*
CVNHP Making of Nations: Vermont's African American Heritage Trail and its Neighbors	NEIWPCC - Hildene	$ 8,850	$2,837,614	*$8,850*	*$0*	*$0*
CVNHP Making of Nations: Sesquicentennial of the 1870 Fenian Attack on Canada	NEIWPCC - Fenian Historical Society	$ 8,850	$2,846,464	*$8,850*	*$0*	*$0*

May 2019 Approved **FY2019 LCBP Budget**

CVNHP Making of Nations: Voting for our Voices: sharing the stories of women's suffrage and civil rights	NEIWPCC - Friends of Crown Pt	$ 5,900	$2,852,364	$0	$0	$5,900
CVNHP Making of Nations: Ladies of the Lake – Women Captains on Lake Champlain	NEIWPCC - LCMM	$ 8,850	$2,861,214	$0	$0	$8,850
Heritage Area Tasks	**Task Management**	**2019 TASK Request**	**TASK Cumulative Total**	**NPS Allocation**	**EPA Allocation**	**GLFC Allocation**
CVNHP Making of Nations: Women of Shelburne: Community Builders, Past to Present	NEIWPCC - Shelburne Historical Society	$ 1,357	$2,862,571	$0	$0	$1,357
CVNHP Special Projects: Lois McClure 2020 Suffrage Voyage	NEIWPCC - LCMM	$ 40,415	$2,902,986	$40,415	$0	$0
CVNHP Special Projects: Saving Spitfire	NEIWPCC - LCMM	$ 23,600	$2,926,586	$0	$0	$23,600
CVNHP Special Projects: Champlain Valley Suffrage Centennial Motorcade	NEIWPCC - Chapman Historical Museum	$ 17,700	$2,944,286	$0	$0	$17,700
CVNHP Special Projects: Suffrage Display Production	NEIWPCC	$ 21,475	$2,965,761	$21,475	$0	$0
Quebec Regional Stakeholder Coordination*	NEIWPCC	$ 2,596	$2,762,354	$0	$0	$2,596
Wayside Exhibit Program Continuation*	NEIWPCC	$ 11,800	$2,774,154	$11,800	$0	$0
Annual International Heritage Summit*	NEIWPCC	$ 9,440	$2,783,594	$0	$0	$9,440
	NHA Totals	**$238,689**	Category Sum	$123,816	$0	$114,873

Education & Outreach	**Task Management**	**2018 TASK Request**	**TASK Cumulative Total**	**NPS Allocation**	**EPA Allocation**	**GLFC Allocation**
E&O Grant Programs (Annual EO local grants (240k), Professional Development (14k), Enhanced Outreach Grants (120k), Boots-n-Bugs 24k)	NEIWPCC	$ 550,500	$3,334,094	$0	$385,350	$165,150
Champlain Basin Education Initiative (CBEI) & Authentic Student Learning	NEIWPCC	$ 24,500	$3,358,594	$0	$0	$24,500
High School Watershed Steward Certification Program, Year 3	NEIWPCC	$ 15,000	$3,373,594	$0	$0	$15,000
Healthy Soils Phase 3	NEIWPCC	$ 72,000	$3,445,594	$0	$72,000	$0
Bioengineering and Shoreland Best Management Practices to Restore Living Shorelands and Protect Water Quality	VERMONT	$ 62,000	$3,507,594	$0	$62,000	$0

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Production of Clean Water Videos	NEIWPCC	$ 35,000	$3,542,594	*$0*	*$0*	*$35,000*
Lake Champlain Education and Outreach Stewards	NEIWPCC	$ 60,000	$3,602,594	*$0*	*$60,000*	*$0*
StreamWise Stewardship	NEIWPCC	$ 61,000	$3,663,594	*$0*	*$0*	*$61,000*
Economic Valuation of Clean Water and Healthy Watersheds	NEIWPCC	$ 5,000	$3,668,594	*$0*	*$0*	*$5,000*
Artist in Residence Program	NEIWPCC	$ 25,000	$3,693,594	*$0*	*$0*	*$25,000*
	E&O Total	**$ 910,000**	Category Sum	$0	$579,350	$330,650
Technical Tasks	**Task Management**	**2019 TASK Request**	**TASK Cumulative Total**	**NPS Allocation**	**EPA Allocation**	**GLFC Allocation**
CORE PROJECT: Lake Champlain Boat Launch Steward Program 2020	NEIWPCC	$ 138,050	$3,831,644	*$0*	*$121,484*	*$16,566*
CORE PROJECT: NEIWPCC-- Lake Champlain Long-Term Water Quality and Biological Monitoring ***(LTMP)***	NEIWPCC	$ 150,000	$3,981,644	*$0*	*$150,000*	*$0*
CORE PROJECT: VERMONT DEC - LTMP	VERMONT	$ 267,629	$4,249,273	*$0*	*$267,629*	*$0*
CORE PROJECT: New York DEC/SUNY Plattsburgh LTMP	NEW YORK - SUNY	$ 185,000	$4,434,273	*$0*	*$185,000*	*$0*
CORE PROJECT: Monitoring Cyanobacteria in Lake Champlain	NEIWPCC-LCC	$ 80,000	$4,514,273	*$0*	*$80,000*	*$0*
CORE PROJECT: Water Chestnut Management Partnership - Lake Champlain Basin	VERMONT	$ 90,000	$4,604,273	*$0*	*$90,000*	*$0*
CORE PROJECT: LCBP Enhanced Grant Awards for Pollution Prevention	NEIWPCC	$ 633,349	$5,237,622	*$0*	*$467,310*	*$166,039*
CORE PROJECT: Aquatic Invasive Species Rapid Response Fund	NEIWPCC	$ 69,900	$5,307,522	*$0*	*$0*	*$69,900*
CORE PROJECT: WWTF Optimization in Lake Champlain Basin - NEW YORK	VERMONT	$ 150,000	$5,457,522	*$0*	*$150,000*	*$0*
CORE PROJECT: WWTF Optimization in Lake Champlain Basin - VERMONT	NEW YORK	$ 110,000	$5,567,522	*$0*	*$110,000*	*$0*
CORE PROJECT: NY Lake Champlain Basin Agronomy Support and Agriculture BMP Implementation	NEIWPCC	$ 160,000	$5,727,522	*$0*	*$160,000*	*$0*
Lake Champlain Basin Dam Removal	NEIWPCC-VNRC	$275,000	$6,002,522	*$0*	*$0*	*$275,000*
Quantifying Phosphorus Reductions for Proposed Projects in NY Reduction Plan	NEIWPCC-LC-LG RPB	$ 82,200	$6,084,722	*$0*	*$0*	*$82,200*
Evaluating Performance of Media Filters to Remove Phosphorus in Stormwater Pond Outflow	NEIWPCC-Stone Environmental	$ 90,000	$6,174,722	*$0*	*$0*	*$90,000*

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Forage fish community monitoring in Lake Champlain	NEIWPCC-UVM	$ 238,822	$6,413,544	*$0*	*$0*	*$238,822*
Targeted interventions to reduce agricultural runoff and erosion in affected areas of the Missisquoi Bay Basin	NEIWPCC-OBVBM	$ 180,000	$6,593,544	*$0*	*$0*	*$180,000*
Technical Tasks	**Task Management**	**2019 TASK Request**	**TASK Cumulative Total**	**NPS Allocation**	**EPA Allocation**	**GLFC Allocation**
Securing and Restoring Aquatic Habitat Connectivity in the North Branch Boquet River Watershed (removed culvert replacement component per EC)	NEIWPCC-The Nature Conservancy	$ 130,000	$6,723,544	*$0*	*$0*	*$130,000*
Quantifying the road salt pollution load to Mirror Lake and the Chubb River (Lake Placid, NY)	NEIWPCC-Ausable River Association	$ 175,000	$6,898,544	*$0*	*$0*	*$175,000*
TMDL Project: Floodplain Restoration and Functional Assessment	VERMONT	$ 600,000	$7,498,544	*$0*	*$600,000*	*$0*
TMDL Project: Innovative CSO Reduction	VERMONT	$ 1,100,000	$8,598,544	*$0*	*$1,100,000*	*$0*
TMDL Project: Internal Loading Assessment and Modeling Study on Missisquoi Bay	NEIWPCC	$ 250,000	$8,848,544	*$0*	*$250,000*	*$0*
TMDL Project: Design and Construction of GSI at Public Schools	VERMONT	$ 1,100,000	$9,948,544	*$0*	*$1,100,000*	*$0*
TMDL Project: Implementation Support Program for Forestry Accepted Management Practices	VERMONT	$ 450,000	$9,298,544	*$0*	*$450,000*	*$0*
TMDL Project: Nutrient Load Source Identification in the Lake Carmi Watershed	NEIWPCC	$ 200,000	$9,498,544	*$0*	*$200,000*	*$0*
TMDL Project: Farm Agronomic Practices (FAP) Program	VERMONT	$ 475,000	$9,973,544	*$0*	*$475,000*	*$0*
TMDL Project: Program to Expand and Accelerate Wetland Conservation and Restoration	VERMONT	$ 1,325,000	$11,298,544	*$0*	*$1,325,000*	*$0*
TMDL Project: Municipal Grants-in-Aid Road-Runoff Reduction and Treatment Program	VERMONT	$ 1,000,000	$12,298,544	*$0*	*$1,000,000*	*$0*
TMDL Project: Enhanced Implementation of VT Environmental Stewardship Program	VERMONT	$ 100,000	$12,398,544	*$0*	*$100,000*	*$0*
	Tech Total	**$ 9,804,950**	Category Sum	*$0*	*$8,381,423*	*$1,423,527*

	Budget	Allocated
EPA FY19 base	**$4,395,000**	$ 4,395,000
EPA-2016 TMDL	**$6,600,000**	$ 6,600,000
NPS (CVNHP)	**$332,097**	$332,097

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GLFC	**$2,380,500**	$2,380,500
	$ 13,707,597	$ 13,707,597

Organization / Core / TMDL	Project	Amount
Core project	Local Implementation Grants PP (300k) / AIS (200k) / OS (50k)	$ 550,000
Core project	Lake Champlain Boat Launch Steward Program 2018	$ 138,050
Core project	Long-term monitoring program	$ 602,629
Core project	Monitoring Cyanobacteria in Lake Champlain	$ 80,000
Core project	Water Chestnut Management Partnership - Lake Champlain Basin	$ 90,000
Core project	LCBP Enhanced Grant Awards for Pollution Prevention	$ 625,000
Core project	Aquatic Invasive Species Rapid Response Fund	$ 69,900
Core project	WWTF Optimization in Lake Champlain Basin	$ 260,000
Core project	NY Lake Champlain Basin Agronomy Support and Agriculture BMP Implementation	$ 160,000
Vermont Natural Resources Council	Lake Champlain Basin Dam Removal	$ 275,000
LC-LG RPB	Quantifying Phosphorus Reductions for Proposed Projects in NY Reduction Plan	$ 82,200
Stone Environmental	Evaluating Performance of Media Filters to Remove Phosphorus in Stormwater Pond Outflow	$ 90,000
UVM Rubenstein	Forage fish community monitoring in Lake Champlain	$ 238,822
OBVBM	Targeted interventions to reduce agricultural runoff and erosion in affected areas of the Missisquoi Bay Basin	$ 180,000
The Nature Conservancy	Securing and Restoring Aquatic Habitat Connectivity in the North Branch Boquet River Watershed (removed culvert replacement component per EC)	$ 130,000
Ausable River Association	Quantifying the road salt pollution load to Mirror Lake and the Chubb River (Lake Placid, NY)	$ 175,000
Vermont Department of Health	Cyanotoxin monitoring in drinking water	$ 8,000
VT TMDL funds	Nutrient Load Source Identification in the Lake Carmi Watershed	$ 200,000
VT TMDL funds	Internal Loading Assessment and Modeling Study on Missisquoi Bay	$ 250,000

TAC recommendation for FY20 priorities

Edited with changes suggested by the Lake Champlain Steering Committee, June 6, 2019.

1. Projects that assess long-term efficacy of water quality BMPs, BMP maintenance practices or develop innovative practices to reduce phosphorus loading
2. Projects that support conservation and/or restoration efforts for
    a. native species and their habitats,
    b. water quality, and/or
    c. flood resilience
3. Research to better understand the water quality impacts of de-icing alternatives and recent changes in de-icing agent application rates
4. Research on Lake Champlain ecosystem impacts of anthropogenic micro- and nanoparticles
5. Research to better understand winter season in-lake biogeochemistry, or watershed nutrient fate and transport

Note: Outside of these priorities, the TAC proposes to develop a recommendation for modest investment in automation within the Lake Champlain Long-Term Monitoring Program. This recommendation will be brought before the Steering Committee for consideration in the FY20 budget deliberations.

Summary of TAC feedback on FY19 priorities/process:

- Priorities were too similar
- Fewer priorities may be better
- Scoring process should be clearer
- Could be a binary option: any priority met or no priorities met
- The condition of whether a priority is met could be determined by staff so it is consistent for all projects (rather than subjectively by TAC).

FY19 priorities:

LCBP seeks pre-proposals for projects that address any strategies and tasks outlined in *Opportunities for Action*. LCBP is particularly interested in funding projects that address the following priorities:

1. Research or innovative demonstration projects that reduce pollution to Lake Champlain, especially nutrients (from agricultural sources, urban stormwater, and legacy nutrients), de-icing agents, and other emerging contaminants of concern

2. Research or implementation projects that use LCBP-funded or other publicly available datasets to create outputs leading to improved water quality in the Lake Champlain Basin

3. Projects that fill knowledge gaps or improve diversity of native aquatic and riparian species in the Lake Champlain Basin (Opportunities for Action Strategy II.B.1; pages 30-31), including habitat restoration and target species recovery

4. Projects that quantify benefits of existing best management practices, or optimize existing practices for pollution reduction goals (Opportunities for Action Task I.A.1.c), especially to reduce soluble reactive phosphorus loading and for management in light of climate change effects

5. Projects that research and support sustainable agricultural practices that address water quality concerns and are economically sustainable (Opportunities for Action Task I.C.2.f)

FY18 priorities:

LCBP seeks pre-proposals for projects that address any strategies outlined in *Opportunities for Action*. LCBP is particularly interested in funding projects that address the following priorities:

1. Innovative pilot or demonstration projects that reduce nutrient loading to Lake Champlain
2. Research or implementation projects that use LCBP-funded or other publicly available datasets to create outputs leading to improved water quality in the Lake Champlain Basin
3. Projects that improve diversity of native aquatic and riparian species in the Lake Champlain Basin (*Opportunities for Action* Strategy II.B.1; pages 37-38)
4. Projects that research or control sources of contaminants in the Lake Champlain Basin (*Opportunities for Action* Strategy I.B.1; pages 28-29)

LCBP 2020—Vermont and New York Projects Priorities (May 30, 2019)

Proposed States Line Items – LCBP will provide funds directly to New York and Vermont to implement these projects

1. Agricultural Nonpoint Source Cost Share Program

   Implementation of best management practices on farms is a cost-effective way to reduce phosphorus and is integral to New York's implementation of the Lake Champlain TMDL. Farmer cooperation and interest in implementation is key to meeting TMDL targets. New York currently provides an annual funding opportunity for agricultural nonpoint source projects with a 75% grant/25% local match requirement through the New York State Department of Agricultural and Markets (DAM). Unfortunately, farms in general (in particular, small dairy farms) have experienced declining net farm incomes and continue to face a challenging economic environment. As such, many farmers are unable to commit to the cost share for project implementation.

   An opportunity exists for the LCBP to provide funding to reduce farmer out-of-pocket expenses for projects. Projects could then be funded mainly by state grants and a portion of the local match covered from LCBP funding. A remaining portion of the local match will still be expected to come from in-kind services from the local soil and water conservation district and/or farm.

   New York DEC and DAM will work with the Champlain Watershed Improvement Coalition of New York (CWICNY), a coalition of five soil and water conservation districts in the Lake Champlain basin, to prioritize projects with the highest nutrient and sediment load reductions for cost share funding. CWICNY will disperse cost share payments to farmers. The overall goal of this program is to double the number of agricultural conservation practices installed in the basin annually.

2. Adapting Municipal Roads General Permit (MRGP) Tools for Mapping and Inventorying Rural, Private, and Forest Roads in Vermont and New York

   Vermont DEC's Municipal Roads General Permit (MRGP) program is a streamlined process for inventorying roads and prioritizing and constructing projects to improve water quality. This relatively simple framework can be adopted to incentivize non-regulatory road best management practices (BMPs) in New York and Vermont. New York state would adopt this framework in partnership with Soil and Water Conservation Districts and municipalities building upon the existing Rural Road Active Management Program. Vermont would adopt this framework on roads not covered by the MRGP, which represent 30% of Vermont road miles, including state forest roads and private roads. This project would involve adopting the MRGP inventory methodology for additional road networks, developing a field application and companion database to gather and store data, and managing a prioritized list of road BMPs to reduce phosphorus loads to Lake Champlain. The resulting prioritized projects would enable potential for subsequent implementation through grants-in-aid/block grant models like Vermont DEC's Municipal Roads Grants-in-Aid program.

3. Developing Assessment and Planning Tools to Implement the Forest Load Allocation of the Lake Champlain TMDL

Forested lands contribute 15 percent of total phosphorus loading to Lake Champlain and the Phosphorus TMDLs for Vermont Segments of Lake Champlain requires a 19 percent reduction in total phosphorus from forested land uses. Even though there is no required TMDL reduction from forested land on the New York side of the watershed, forested land does contribute 9.2 percent of the total phosphorus loading to Lake Champlain. Phosphorus reductions from forested land uses will primarily involve remediating erosion and altered hydrology associated with forest trails and roads and legacy logging operations. Due to the remote nature of these sites, New York and Vermont are seeking support for assessment work required to identify and prioritize project opportunities and develop an implementation plan to achieve TMDL load reductions in forest land. The resulting prioritized projects would inform future state and federal investments to support implementation of the TMDL.

Priorities for Request for Proposals – These will be called out in the Technical Project RFP as priority areas that will receive additional scores in ranking

1. Evaluation of existing BMP performance and design standards in relation to climate change

   NY and VT support a precautionary response to climate change-driven impacts. In recognition that Lake Champlain's phosphorus loading problems are largely associated with precipitation-driven runoff and erosion across all land uses, both states need to minimize current and future climate-change-induced phosphorus loading. In other words, are best management practices designed to appropriate standards to accommodate changes in climate?

2. Management recommendations to extend best management practice life span and performance

   Best management practices to reduce nutrients and sediment function for a defined number of years (lifespan) before the practice no longer removes pollutants from the environment and must be replaced. Both New York and Vermont have invested substantial resources to install a significant number of practices in the Lake Champlain Basin to remove phosphorus and sediment. Instead of replacing those practices that have reached the end of their useful lifespan, it would be more cost effective to find ways to extend the expected lifespan of those stormwater practices. There is a need for research to determine management activities that would extend the useful life of practices and also retain pollutant removal efficiencies over time. Extension of the life span of stormwater practices could take the form of specific operation and maintenance of the practices, or by retrofitting the practices with specific measures toward the end of the life of the practices.

3. Evaluate techniques to increase the efficiency of best management practices in removing soluble reactive phosphorus

   Soluble reactive phosphorus is like a rocket fuel for algal growth. The majority of current phosphorus reduction stormwater practices are effective in removing phosphorus (particulate phosphorus) that is typically adhered to sediment. Soluble reactive phosphorus is the dissolved and immediately bio-available form of phosphorus in stormwater. It is important to remove soluble reactive phosphorus in addition to particulate phosphorus from stormwater discharges. Results from this type of research would enhance reduction of the phosphorus that is immediately biologically available for the growth of algae. Information collected through these types of studies would support updates to state design manuals and inform the use of state funding mechanisms.

4. <u>Habitat restoration and target species recovery</u>

   Protecting and restoring floodplains and wetlands, including their functions and connectivity, will improve fish and wildlife habitat, water quality, and flood resilience. In addition, projects that enhance aquatic connectivity through aquatic organism passage and barrier removal; and those that support sturgeon recovery are priorities.

5. <u>Quantifying flood storage capacity and nutrient load reductions resulting from natural resources conservation and restoration</u>

   Protecting and restoring wetland and floodplain functions are integral to meeting phosphorus TMDL targets and reducing the risks and impacts of flooding, but we need additional investment in research to better understand and develop tools for assessing project-specific flood storage capacity and nutrient load reductions achieved through floodplain and wetland protection and restoration.

6. <u>Evaluate alternatives to chloride use for private contractors (e.g., commercial, industrial and private parking lots, airports, private roads, residential driveways) in NY and VT</u>

   A research project could evaluate the use of alternative chemicals that are less corrosive than chloride, like live edge plowing, and other snow and ice management actions.

<u>Education and Outreach – These are New York and Vermont's priority education and outreach</u>

1. <u>Enhancing understanding of and tracking education and outreach outcomes for Vermont and New York through pilot watersheds</u>

   This project would pilot established methods for using social indicators to evaluate education and outreach outcomes at a sub-watershed scale, which will help us better understand the impact of outreach activities and direct future outreach initiatives to better address barriers to and incentivize actions that improve water quality.

2. <u>Lake shoreland best management practices in Vermont and New York</u>

   This project would support the development of outreach and assessment materials and provide assessment and training opportunities for restoring living shorelands using best management practices to enhance habitat and protect water quality.

Concentration, load, and trend estimates for nutrients, chloride, and total suspended solids in Lake Champlain tributaries, 1990 – 2017

Technical report prepared by

Matthew C.H. Vaughan, PhD

for the

Lake Champlain Steering Committee

Approved by the

Lake Champlain Basin Program Technical Advisory Committee

April 3, 2019

NEIWPCC
New England Interstate Water Pollution Control Commission

Lake Champlain Basin Program

Although the information in this document may have been funded by the International Great Lakes Fishery Commission through their contracts to NEIWPCC, it has not undergone review by the Commission, and no official endorsement of the content of the document should be inferred.

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http://lcbp.org/techreportPDF/86_LC_Tributary_Loading_Report.pdf

First released May 30, 2019.

Revision released June 3, 2019. This version includes corrections to Tables 3-12 and some text that refers to trend results for first half of record.

Executive Summary

Purpose and scope

Lake Champlain is a treasured natural resource and the subject of several water quality restoration goals. Determining the amount of water, nutrients, and sediment delivered to the lake each year by major tributaries is critical to inform management objectives. This report compiles water quality and discharge data for 18 major tributaries to Lake Champlain to examine concentration, load, and trends for key water quality parameters: total phosphorus, dissolved phosphorus, total nitrogen, chloride, and total suspended solids. The influence of annual water flux variability was reduced with a flow-normalization technique. Trends in flow-normalized concentration and load were considered for three time periods for all parameters: full record, and the first and second halves of record. Model biases were generally within acceptable limits for all constituents besides total suspended solids, where concentrations and loads were often over-estimated. Models and results were generated using custom automated programming code using R statistical software, which will reduce the time and cost required for future iterations of this report to be generated for Lake Champlain Basin stakeholders.

Total phosphorus

The Winooski and Missisquoi Rivers, Lake Champlain's two largest tributaries, each contributed roughly 100 to 300 metric tons of phosphorus to the lake most years. In 10 out of the 18 tributaries, no trends in flow-normalized total phosphorus load were found for any time period. Flow-normalized total phosphorus load decreased in the Little Ausable River throughout the period of record. Flow-normalized loads decreased sharply in the first half of the record for the LaPlatte River, but no trends were found in the second half of the record. Lewis and Little Otter Creeks showed significant increases in flow-normalized load for entire record. For the Missisquoi and Poultney Rivers and Putnam Creek, increasing trends were only found in the second half of the record.

Dissolved phosphorus

Dissolved phosphorus loads ranged from roughly 20 to 80 metric tons per year for the Missiquoi River and Otter Creek, and roughly 10 to 40 metric tons per year for the Winooski and Pike Rivers. Seven out of the eighteen tributaries showed no trend in flow-normalized dissolved phosphorus load for all of the three trend periods considered. The LaPlatte River showed a significant decrease in flow-normalized load throughout record, and Otter Creek and Winooski River showed a significant decrease for the first half of the record and full-record trend periods, but not for the second half of record. There were significant increases in flow-normalized load for several tributaries in the first half of record and full record trend periods, including: Ausable, Boquet, Salmon, and Saranac Rivers and Putnam Creek. Of these, only the Putnam Creek continued to increase in flow-normalized load in the second half of record; no trend in the second half of record was observed for the others.

Total nitrogen

The Winooski and Missisquoi Rivers each delivered roughly 750 to 2,000 metric tons of nitrogen to Lake Champlain most years. The Pike River annual flow-normalized total nitrogen yield often exceeded that of other tributaries by a factor of two and Pike River annual mean total nitrogen concentrations were much higher than other tributaries. Trends, mostly downward, in flow-normalized load were found for at least one trend period for all but three tributaries. Flow-normalized total nitrogen load significantly decreased for all three trend periods in the Saranac River. Six tributaries decreased in flow-normalized total nitrogen load for the full record trend period: the LaPlatte, Mettawee, Saranac, and Salmon Rivers, and Otter and Putnam Creeks. The Ausable, Boquet, and Little Chazy Rivers showed no trend for the first half of record, then had significant decreases in the second half of the record. Significant increases in flow-normalized load for the second half of record were found in the Great Chazy River and the Little Otter Creek.

Chloride

The Winooski River delivered roughly 15,000 to 45,000 metric tons of chloride to Lake Champlain each year; its loads and yields often exceeded those of other tributaries. The LaPlatte River had the highest flow-normalized chloride concentration for much of the record, though this decreased significantly and was similar to the Winooski and Mettawee Rivers in 2017. Full-record significant increases in flow-normalized chloride load were observed in all but two tributaries, the LaPlatte and Pike Rivers, where decreasing trends were found. For six tributaries that had significant first half and full record increases, there was no trend or a decreasing trend in flow-normalized chloride load for the second half of record: Ausable, Boquet, Missisquoi, and Winooski Rivers, and Lewis and Otter Creeks.

Total suspended solids

Winooski and Missisquoi Rivers had the highest annual total suspended solids loads, at times exceeding an estimated 200,000 metric tons per year. Five tributaries had significantly increasing trends in flow-normalized total suspended solids load for the full record: LaPlatte, Missisquoi, and Pike Rivers, and Lewis and Little Otter Creeks. Of these, only Little Otter Creek had an increasing trend in the second half of record; the others had no trend. The Lamoille River was the only tributary to show a decreasing trend in flow-normalized total suspended solids load for the full record trend period. The Little Ausable and Little Chazy Rivers had relatively low chloride loads and yields, and both decreased significantly in the second half of record.

Water

Annual water fluxes for Lake Champlain tributaries were closely related to contributing watershed area, and larger watersheds generally had greater runoff per land area. The Winooski and Missisquoi Rivers delivered roughly one to three billion cubic meters of water to Lake Champlain most years. There were no trends in water flux for the full record or for the first half record for any tributary. For the second half of record, the Boquet, Mettawee, Otter, and Poultney Rivers and Putnam Creek showed significant decreases in annual water flux.

Introduction

Purpose of study

Lake Champlain is a treasured natural resource situated in the US states of New York and Vermont, and the Canadian Province of Québec (Figure 1). Its tributaries deliver water, nutrients, sediment, and pollutants to the lake from a drainage basin that is roughly 18 times the size of the water body. The lake and its tributaries are the subject of several restoration efforts. To inform these restoration efforts, the Lake Champlain Basin Program supports the Long-term Water Quality and Biological Monitoring Program for Lake Champlain (LTMP) in collaboration with New York and Vermont Departments of Environmental Conservation and the New England Interstate Water Pollution Control Commission. This program has collected extensive water quality and aquatic community data since 1990, including 22 Lake Champlain tributary monitoring stations where key water quality parameters are measured several times per year. In addition, the U.S. Geological Survey has recorded estimates of discharge on many of these major Lake Champlain tributaries every 15 minutes over the same time period.

The Lake Champlain Basin Program LTMP and US Geological Survey datasets provide the opportunity to consider historical records, variability, and changing trends of the delivery of water, nutrients, sediment, and chloride delivery to the lake since 1990. This analysis is central to *Opportunities for Action: An Evolving Plan for the Future of the Lake Champlain Basin*, which calls for the assessment of progress toward established water quality targets. Secondly, it informs the Lake Champlain Basin Program's *State of the Lake and Ecosystem Indicators Report*, which disseminates the latest scientific knowledge in a document accessible to all stakeholders in the Lake Champlain Basin.

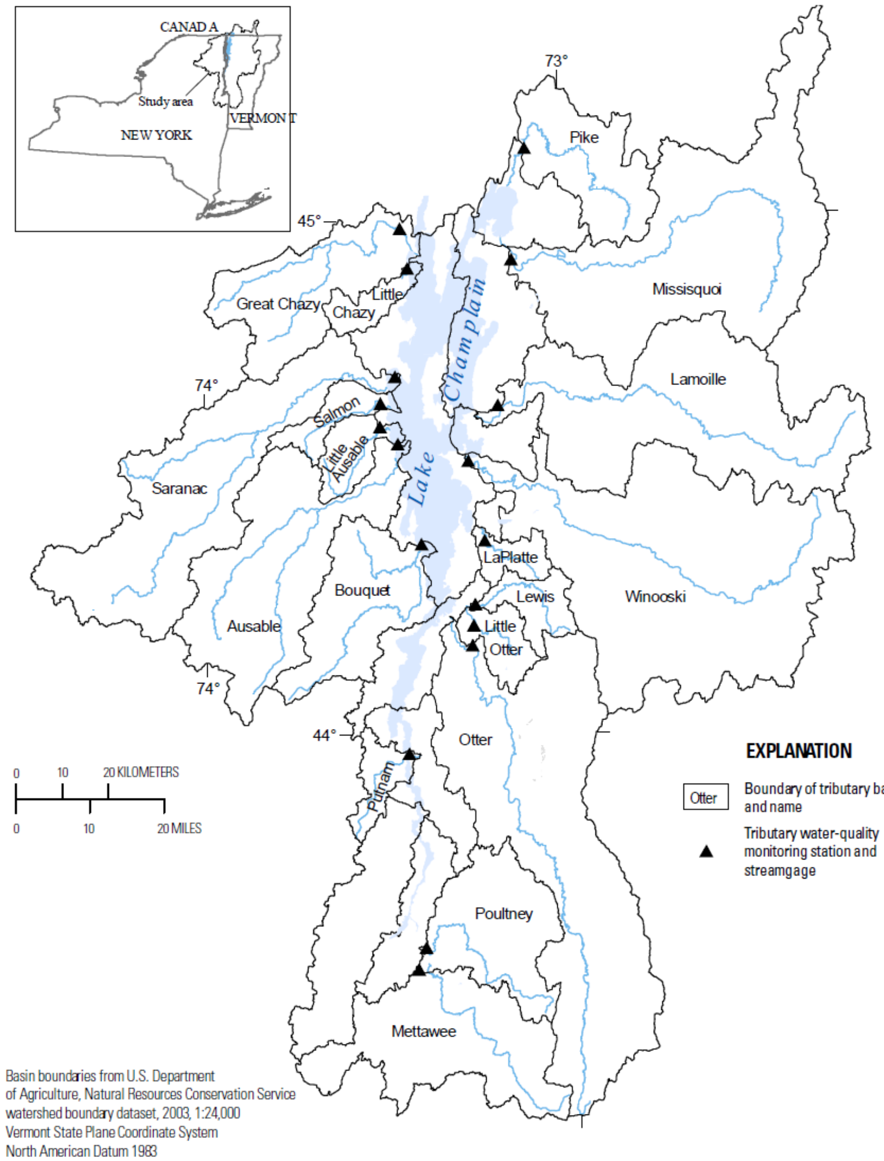


Figure 1. Map of Lake Champlain, its drainage basin, major tributaries, and co-located long-term monitoring and stream gauge stations (Medalie 2016).

Summary of past efforts to estimate Lake Champlain tributary loads

Several past efforts have calculated concentrations, loads, and trends for Lake Champlain tributaries. The Lake Champlain Diagnostic-Feasibility Study (1997) was the first major effort to document tributary concentrations and loads of total phosphorus, dissolved phosphorus, and chloride. At that time, water samples and continuous discharge measurements were collected at 31 tributaries of Lake Champlain. Also among the earliest efforts was Medalie and Smeltzer (2004), where tributary total phosphorus concentrations were summarized, and loads were calculated for 18 major tributaries using the U.S. Army Corps of Engineers FLUX program

(Walker 1987; Walker 1996). In this study, trends were determined using two separate methods, including the ESTIMATOR program (Cohn et al. 1992) and a time-series moving average approach (Vecchia 2000). In Smeltzer and Simoneau (2008), phosphorus loads were estimated for tributaries of Missisquoi Bay from 2002 – 2005 using the FLUX program. This was also the first study to incorporate laboratory phosphorus measurements from the LTMP and the Québec Ministère du Environnement et Lutte contre les changements climatiques (MELCC) to estimate phosphorus load for the Pike River, which flows through the two nations. Although methodological differences likely caused results from the two labs to be significantly different, a linear regression model was used to adjust the data for inclusion into the FLUX model.

Medalie et al. (2012) was the first to estimate load trends for 18 of Lake Champlain's major tributaries using the weighted regression on time, discharge, and season (WRTDS) model. This method was then repeated and updated with iterative improvements in Medalie (2013), Medalie (2014), and Medalie (2016). The latest effort considered data from 1990 – 2014, included uncertainty estimates for the first time, and omitted estimates for the winter season. In addition, Patoine (2017) used the same model to estimate phosphorus loads from 2009 to 2012 for all MELCC monitored streams in Québec, including the Pike River.

Phosphorus load estimates for Lake Champlain have been made in the development of Total Maximum Daily Load (TMDL) determinations for the states of New York (New York and Vermont DECs, 2002) and Vermont (EPA, 2016). Both efforts were based on the BATHTUB modeling program (Walker 1987) and Lake Champlain Basin Program LTMP data. The Vermont TMDL for Lake Champlain segments also incorporated the Soil and Water Assessment Tool (SWAT) model to determine phosphorus loads from areas that are outside of monitored tributary watersheds.

Goals of this work

The goals of this work are to consider available data for discharge, phosphorus, nitrogen, chloride, and suspended sediment for the major tributaries of Lake Champlain to determine

1. annual mean concentration estimates for each constituent;
2. annual load estimates for each constituent; and
3. mid-term and long-term trends in concentration and load estimates with associated uncertainties.

Among many factors, annual constituent tributary loads and concentrations are driven by precipitation and annual water flux, which are highly variable in the Lake Champlain Basin's humid climate. Flow-normalization by the WRTDS model is a method to reduce the influence of annual variability in water flux and determine water quality trends that may be attributed to watershed restoration efforts and/or environmental stressors.

Methods

The LTMP collects water samples and tributary data at 22 tributary sites; 18 of these sites have sufficient records for the WRTDS analysis (Table 1). Available records began in 1990 for total phosphorus, dissolved phosphorus, and chloride. For total nitrogen and total suspended solids, records began in 1992. Detailed methods on sample collection can be found in the LTMP Quality Assurance Project Plan (Appendix A). These concentration measurements were paired with measurements of discharge by the U.S. Geological Survey at 17 of the 18 sites, and by the MELCC at the Pike River.

Estimates and trends for concentration and loads for water quality parameters were calculated using WRTDS models generated with the EGRET package in R (Hirsch et al. 2010; R Core Team 2015). This flexible statistical method is intended to provide estimates of actual concentrations and fluxes, and artificial estimates that reduce the influence of annual water flux variability. Its regression to predict concentration values for any given day is based on a model that weights time, discharge, and season. This regression takes the basic form

$$\ln(c) = \beta_0 + \beta_1 t + \beta_2 \ln(Q) + \beta_3 \sin(2\pi t) + \beta_4 \cos(2\pi t) + \varepsilon \,, \qquad (1)$$

where c is the estimated concentration, β values are fitted coefficients, t is the time of the estimate in fractional years, Q is daily mean discharge on the day of estimate, and ε is a residual term. The fitted coefficients are determined using weights that correspond to the multi-dimensional “distance” of the estimate from known sample concentrations. This is determined by the equation

$$w = \begin{cases} (1-(d/h)^3)^3 & \text{if } |d| \le h \\ 0 & \text{if } |d| > h \end{cases} \,, \qquad (2)$$

where w is the weight used for regression, d is the “distance” from the estimate point to the known sample concentration point, and h is the half-window width, a user-specified input. This function approximates a normal distribution with a flat top of the bell curve and tails equal to zero past the half-window width, rather than asymptotic tails. More detail on how these weights determine regression coefficients can be found in Hirsch et al. (2010).

Flow-normalized estimates are intended to reduce the influence of annual variability in water flux. These estimates are computed in a similar way as actual estimates, though instead of using the actual daily mean discharge for each estimate, the algorithm uses the mean of estimates using all discharge measurements observed at each site on the date of estimate. For example, if estimating concentration on May 1, 2000, the model computes estimates using discharges for each observed May 1 on record, then calculates the mean of these estimates.

WRTDS models and all results were generated using custom R programming code that automated calculations, compilation, and graphical presentation. User-specified parameters were identical to Medalie (2016) and most water quality and discharge data was retrieved automatically through online databases and incorporated into model calculations. This programming infrastructure will reduce the time and cost required for future iterations of this report to be generated for Lake Champlain stakeholders. All resulting data generated from this report, including daily and annual estimates of concentration and load for all parameters and tributaries, can be found in Appendix B.

One notable difference from Medalie (2016) is that annual estimates were generated for full years rather than non-winter periods only. Although winter water quality sample data is sparse and including the winter period may introduce uncertainty to estimates, watershed managers and other stakeholders have expressed a preference for full-year estimates in order to compare results to nutrient load targets and regulations.

A second notable difference from Medalie (2016) is the addition of Québec MELCC phosphorus concentration data to Pike River total phosphorus concentration estimates from the LTMP. From the earliest record until March 2009, MELCC total and dissolved phosphorus concentrations were determined by automated colorimetric method using ammonium molybdate. From April 2009 until the present, these concentrations were determined by acid-persulfate digestion, as with LTMP samples. Where appropriate, a conversion factor was applied to MELCC laboratory results based on the correlation demonstrated by Smeltzer and Simoneau (2008).

The discharge gauging stations for the Little Chazy River was discontinued on September 30, 2014, and then resumed operation on October 1, 2015. In order to generate estimates and calculate trends, the missing year of record was estimated using a linear correlation of available daily mean discharge values at Little Chazy River gauge with the nearby Great Chazy River gauge. The linear model incorporated 9,406 days of data and was highly significant ($p < 0.001$) with an adjusted R^2 of 0.81.

Table 1. Tributary information and dates used in the analysis. Note that the tributaries are sorted in descending order by watershed area. The Pike River gauge number corresponds to the MELCC gauge network. The mean annual water flux is for years considered in this report.

Tributary	Watershed area (km^2)	Mean annual water flux (10^9 m^3)	USGS gage number	STORET station number	Date of first estimate for TP, TDP, Cl	Date of first estimate for TN, TSS	Date of last estimate for all parameters
Winooski	2704	1.80	4290500	501903	1990-03-01	1992-06-01	2017-11-30
Missisquoi	2201	1.63	4294000	500505	1990-03-01	1992-06-01	2017-11-30
Lamoille	1777	1.27	4292500	501794	1990-03-01	1992-06-01	2017-11-30
Otter	1627	1.02	4282500	500509	1990-03-01	1992-06-01	2017-11-30
Saranac	1575	0.91	4273500	500491	1990-03-01	1992-06-01	2017-11-30
Ausable	1155	0.73	4275500	500500	1990-03-01	1992-06-01	2017-11-30
Bouquet	699	0.34	4276500	500498	1990-03-01	1992-06-01	2017-11-30
Great Chazy	629	0.32	4271500	500492	1990-03-01	1992-06-01	2017-11-30
Pike	584	0.33	30424	500512	1990-03-01	1992-06-01	2017-11-30
Poultney	484	0.25	4280000	500578	1990-03-01	1992-06-01	2017-11-30
Mettawee	433	0.25	4280450	500508	1990-03-01	1992-06-01	2017-11-30
Lewis	200	0.10	4282780	500503	1990-03-01	1992-06-01	2017-11-30
Little Ausable	176	0.05	4273800	500501	1991-10-01	1992-06-01	2017-11-30
Salmon	164	0.06	4273700	500502	1990-03-01	1992-06-01	2017-11-30
Little Otter	148	0.06	4282650	501371	1990-03-01	1992-06-01	2017-11-30
Putnam	134	0.07	4276842	500495	1990-03-01	1992-06-01	2014-09-30
Little Chazy	130	0.06	4271815	500490	1990-03-01	1992-06-01	2017-11-30
LaPlatte	116	0.05	4282795	501594	1990-03-01	1992-06-01	2017-11-30

Annual concentration estimates and uncertainties

Annual concentration estimates were calculated in three ways: (1) time-weighted mean concentration, (2) flow-weighted mean concentration, and (3) flow-normalized concentration. The time-weighted mean concentration for a given year is the arithmetic mean of all estimated daily concentration values for each tributary and year. Flow weighted concentration is given by the equation,

$$C_{FWM} = \frac{\sum c_i q_i t_i}{\sum q_i t_i}, \quad (3)$$

where C_{FWM} is the annual flow-weighted mean concentration, c_i is the daily concentration on the i^{th} day of the year, q_i is the daily discharge on the i^{th} day of the year, and t_i is the time duration of the i^{th} day of the year. This results in the equivalent of the total mass flux divided by the total flux volume of water. In other words, if the tributary hypothetically flowed into a bucket that was well mixed at the end of the year, its concentration would equal the flow-weighted mean concentration. The difference between the flow-weighted and time-weighted concentrations indicates the importance of high discharge events (storms and snowmelt) on the bulk concentration of water delivered to Lake Champlain. The annual flow-normalized concentration was found by calculating the arithmetic mean of all daily flow-normalized concentration values for each tributary and year. Confidence intervals (95%) for annual flow-normalized concentration values were generated using the EGRETci package in R.

Annual load estimates and uncertainties

Annual loads for each site were estimated by multiplying daily concentration estimates by daily mean discharge estimates, then summing each of these daily load estimates to attain a total load for each year. Annual flow-normalized load was calculated in a similar way, but using flow-normalized concentrations rather than actual concentration estimates. Confidence intervals (95%) for annual flow-normalized load estimates were generated in the same way as those for flow-normalized concentration estimates. Annual yield estimates were calculated by dividing the annual load estimates by the contributing watershed area for each tributary. Similarly, annual water yield estimates were calculated by dividing the annual water flux estimates by the contributing watershed area for each tributary, and converting units to millimeters.

The flux bias statistic is a dimensionless diagnostic metric that indicates the difference between modeled and observed loads for each WRTDS model. It is calculated by the difference of the mean predicted flux and the mean observed flux, divided by the mean observed flux. Flux bias values outside of the range of −0.1 to +0.1 (representation a range of ±10% error) may indicate that the model has an unacceptable level of uncertainty (Hirsch 2014; Medalie 2016).

Trends and uncertainties

Trends and associated uncertainties were calculated for three different time periods at each site and parameter: the full record, beginning of record to 2004 (hereafter "first half"), and 2004 to the end of record (hereafter "second half"). Records used for trends in total phosphorus, dissolved phosphorus, and chloride begin in 1991 for all tributaries besides Little Ausable River, which began in 1992. Records used for trends in total nitrogen and total suspended solids began in 1993 for all tributaries. The last year of record used for trend analyses was 2017 for all tributaries besides Putnam Creek, where 2013 was used as the final year due to discharge data availability.

The probability of a statistically significant trends in flow-normalized concentration and load was determined using the EGRETci R package, which uses a bootstrap test using Monte Carlo simulations to estimate the probability of detecting a trend when a trend is not present. Model parameters replicated those of Medalie (2016) (100 bootstrap replicates, 40 or more replicates, and 200 days in a bootstrap block). Trends were determined to be significant if their probability of being different from zero was greater than or equal to 90%. Changes from the first year of trend to the last year of trend are reported, as well as the annualized percent change provided by the equation:

$$c_a = \left(\frac{v_f}{v_i}\right)^{\frac{1}{y}} - 1 \,, \tag{4}$$

where c_a is the annualized percent change, v_f is the final value in the trend period, v_i is the first value in the trend period, and y is the duration of the trend period in years. Note that this metric differs from previous reports on Lake Champlain tributary trends and reflects the annual percent change expected from year to year.

Monotonic trends in annual water flux were determined by the nonparametric Mann-Kendall test, and rates of change were determined by Sens slope estimator, which is equivalent to the median of the slopes of all pairs of data used in each test (Helsel and Hirsch 2002).

Results and discussion

Model performance

Flux bias statistics for each model (Table 2) indicate that most models were validated within an acceptable amount of prediction error. For total phosphorus, models were acceptable for 16 out of 18 tributaries. Flux bias statistics for Putnam Creek and Saranac River were less than -0.1, indicating that total phosphorus concentrations and loads may be underpredicted. All models predicting dissolved phosphorus concentrations and loads were acceptable besides that for Saranac River, which tended to underpredict concentrations and loads. All WRTDS models for total nitrogen and chloride were validated with acceptable flux bias statistics.

Of the 18 WRTDS models for total suspended solids, only six were validated with an acceptable flux bias statistic value. Of 12 others that had large errors, 10 tended to overpredict total suspended solids concentrations and loads, and two tended to overpredict them. Total suspended solids often have a nonlinear relationship with discharge, and these relationships may not be adequately captured by the WRTDS method (Hirsch et al. 2010; Medalie 2016).

Table 2. Flux bias statistics (unitless) for each WRTDS model. Values less than -0.1 and greater than +0.1 are outlined and shown in **bold**.

Tributary	Total phosphorus	Dissolved phosphorus	Total nitrogen	Chloride	Total suspended solids
Ausable	0.007	-0.041	-0.044	-0.022	**0.221**
Boquet	0.058	0.075	0.057	-0.028	**0.371**
Great Chazy	-0.014	-0.005	-0.001	-0.014	**0.129**
Lamoille	-0.058	0.024	-0.007	-0.020	**-0.138**
LaPlatte	0.063	0.084	0.011	0.000	**0.130**
Lewis	0.007	-0.091	-0.013	-0.004	**0.109**
Little Ausable	-0.069	-0.025	0.013	-0.018	**0.118**
Little Chazy	-0.019	-0.006	0.001	-0.009	0.015
Little Otter	-0.008	-0.002	0.014	-0.009	0.037
Mettawee	0.071	0.009	0.000	-0.001	**0.217**
Missisquoi	-0.017	0.005	-0.027	-0.016	0.063
Otter	-0.016	0.008	-0.017	-0.013	0.006
Pike	-0.003	0.026	-0.034	-0.009	0.035
Poultney	0.007	-0.005	-0.011	-0.004	**0.116**
Putnam	**-0.138**	-0.028	-0.043	-0.035	-0.013
Salmon	-0.035	-0.072	-0.014	0.015	**0.117**
Saranac	**-0.216**	**-0.170**	-0.013	-0.020	**-0.686**
Winooski	0.012	-0.020	-0.010	-0.017	**0.133**

Total phosphorus

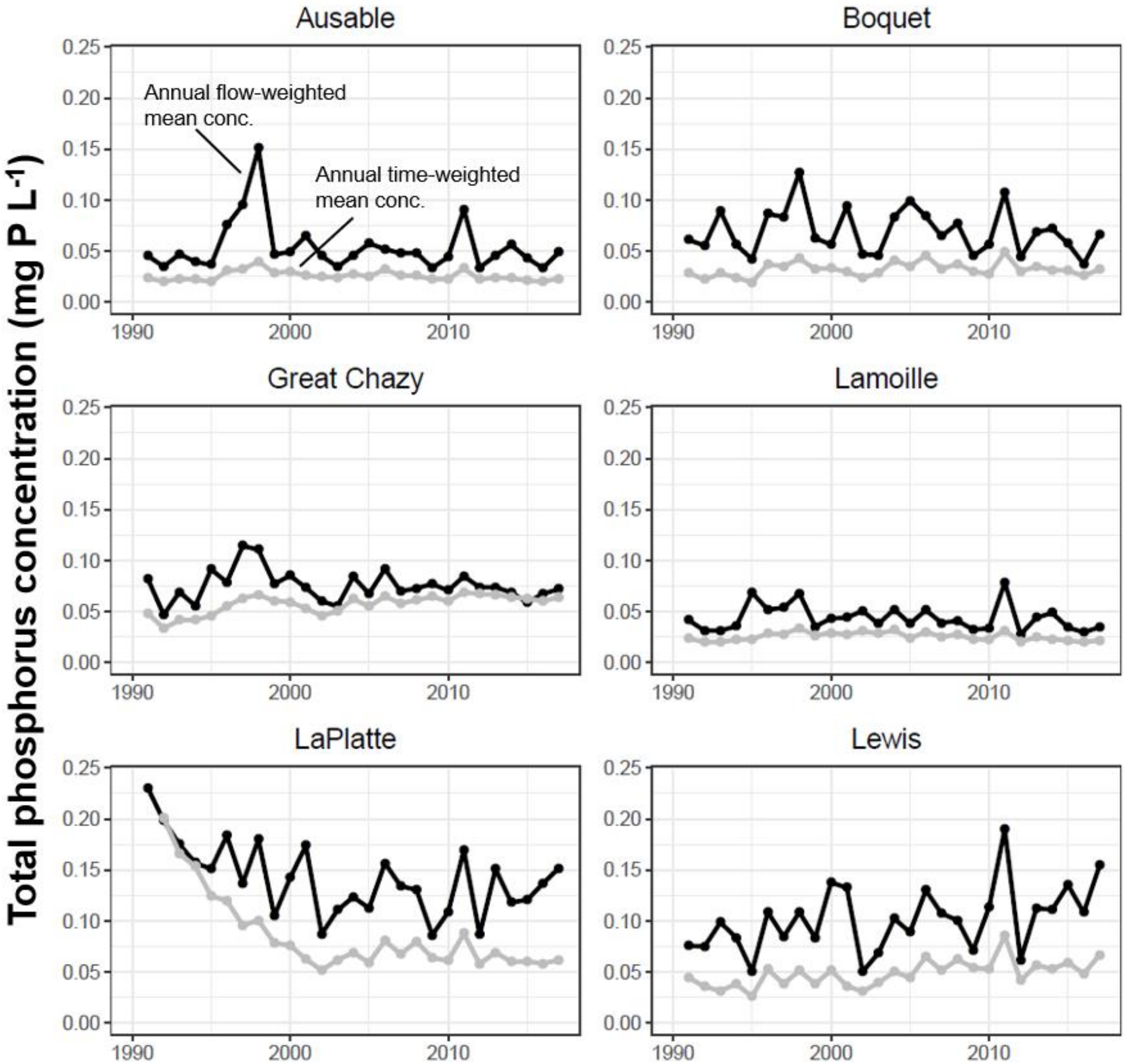
Annual time- and flow-weighted mean total phosphorus concentrations demonstrate the influence of annual hydrologic variability on phosphorus concentration (Figure *3*). Flow-weighted mean concentrations tend to be higher than time-weighted mean concentrations for total phosphorus because total phosphorus trends to increase with higher discharge.

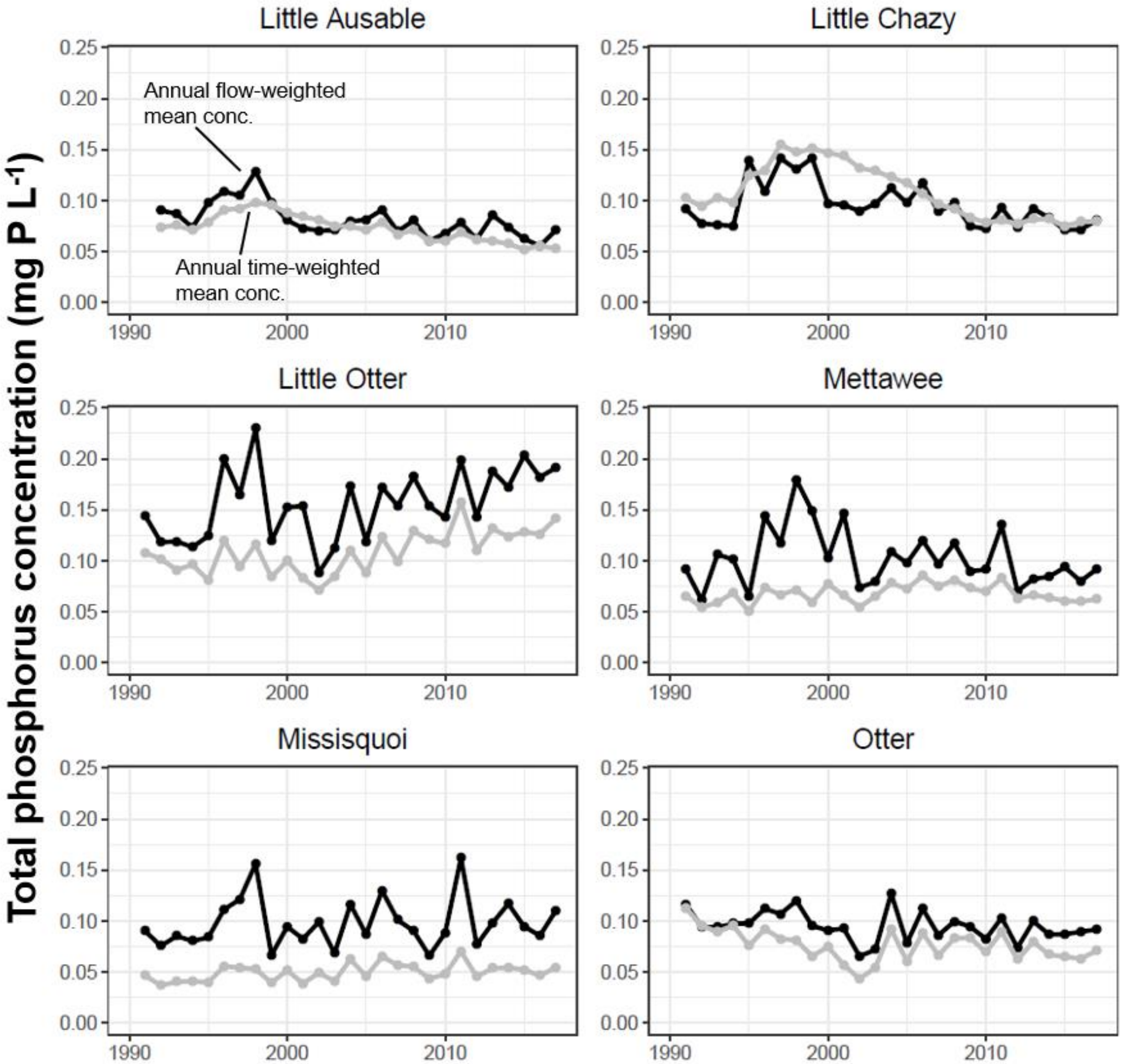
Monte Carlo simulations revealed that there were no trends in total phosphorus concentration during any of the three trend periods for 7 out of the 18 tributaries (Figure *3*, Table *3*). The LaPlatte and Pike Rivers and Otter Creek showed significant flow-normalized concentration decreases in the first half of the record, but these trends were not found in the second half of the record. Lewis, Little Otter, and Putnam Creeks all increased in flow-normalized concentration for full record and second half trend periods. Finally, the flow-normalized concentration in the

Missisquoi River increased slightly for the full record timeframe, but no significant trends were found for half record timeframes.

Annual total phosphorus loads were also influenced by hydrologic variability and this effect was artificially reduced in annual flow-normalized loads for trend analyses (Figure *4*). Although the largest tributaries generally had the highest loads (e.g., Winooski and Missisquoi Rivers), the Pike River had the highest flow-normalized total phosphorus yield (load per watershed area) for the entire record (Figure 5). The Little Ausable, Saranac, and Salmon Rivers and Putnam Creek were among the tributaries with the lowest annual flow-normalized total phosphorus yields.

In 10 out of the 18 tributaries, no trends in flow-normalized total phosphorus load were found for any of the three trend periods (Table 4). Flow-normalized loads decreased strongly in the first half of the record for the LaPlatte River and over the full record timeframe, but no trends were found in the second half of the record. Lewis and Little Otter Creeks showed significant increases in flow-normalized load for full and second half trend periods. For the Missisquoi and Poultney Rivers and Putnam Creek, trends were only found in the second half of the record, where trend probabilities were high (> 97%).


Ausable
Boquet
Great Chazy
Lamoille
LaPlatte
Lewis
Annual flow-weighted mean conc.
Annual time-weighted mean conc.
Total phosphorus concentration (mg P L-1)
0.25
0.20
0.15
0.10
0.05
0.00
1990
2000
2010


Little Ausable
Little Chazy
Little Otter
Mettawee
Missisquoi
Otter
Annual flow-weighted mean conc.
Annual time-weighted mean conc.
Total phosphorus concentration (mg P L-1)
0.25
0.20
0.15
0.10
0.05
0.00
1990
2000
2010

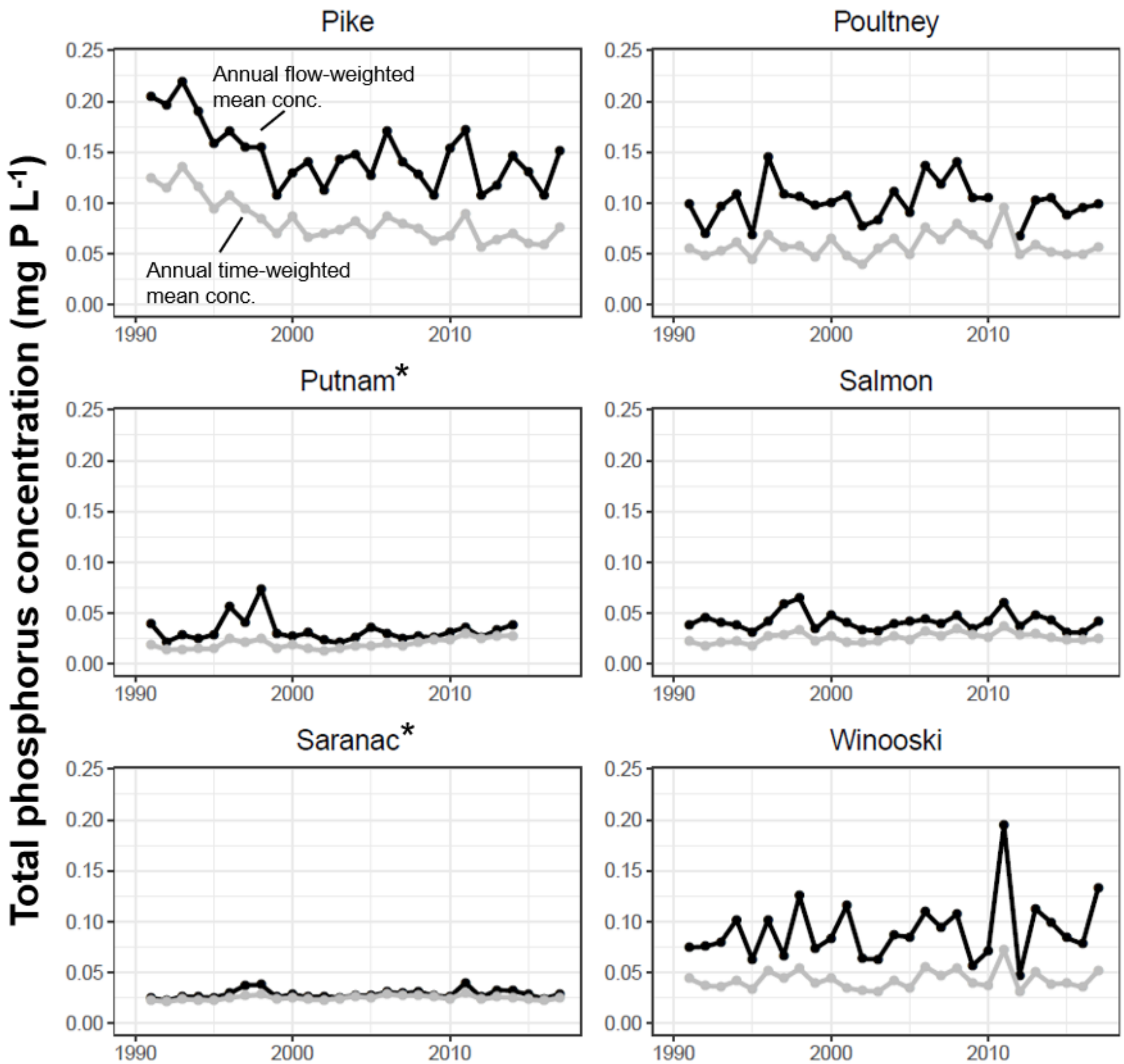


Figure 2. Estimated annual flow-weighted mean (black dots and lines) and time-weighted mean (grey dots and lines) total phosphorus concentrations for eighteen Lake Champlain tributaries. An asterisk (*) indicates that the flux bias statistic was outside of the acceptable range and that the results should be interpreted with care.

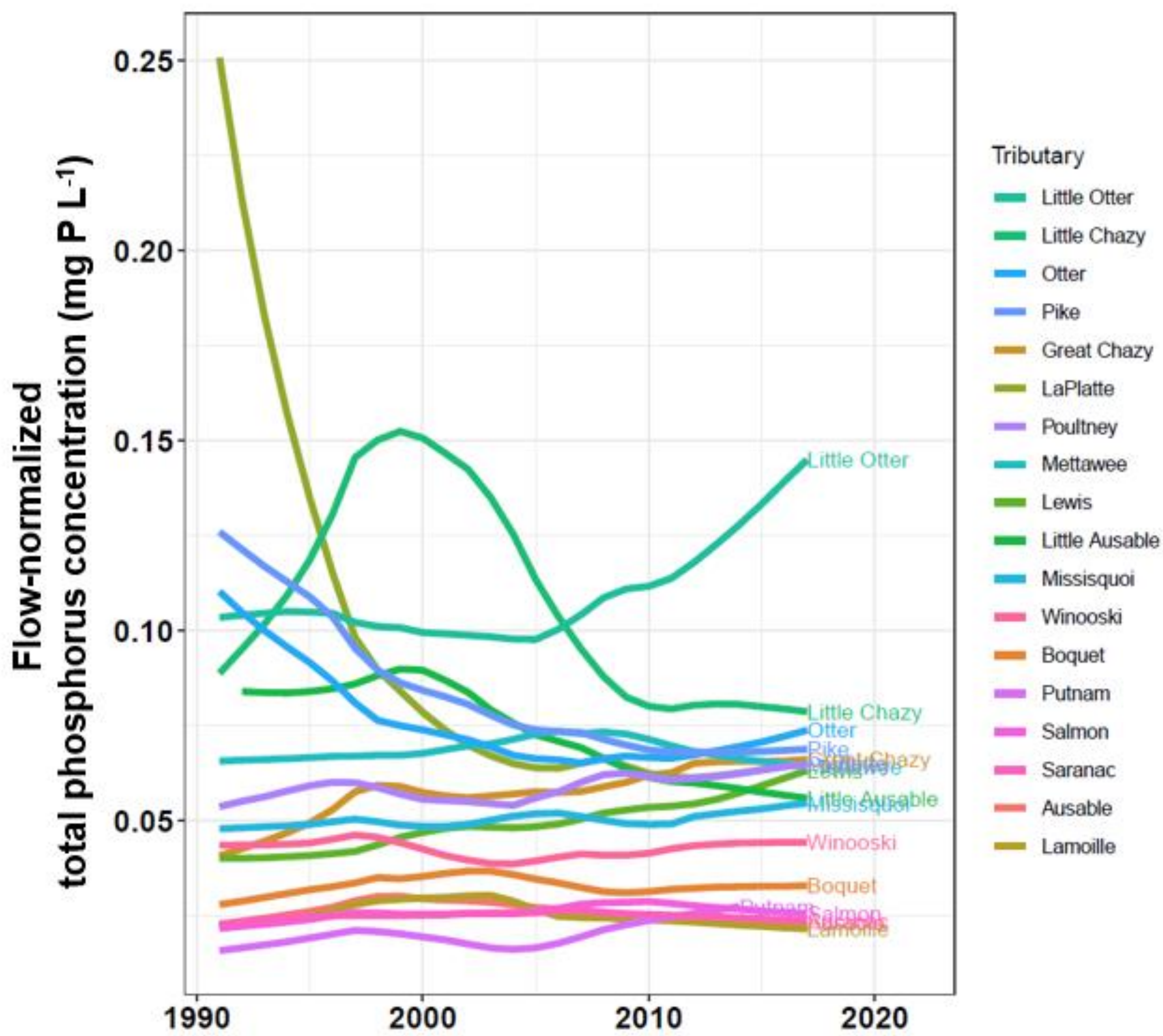
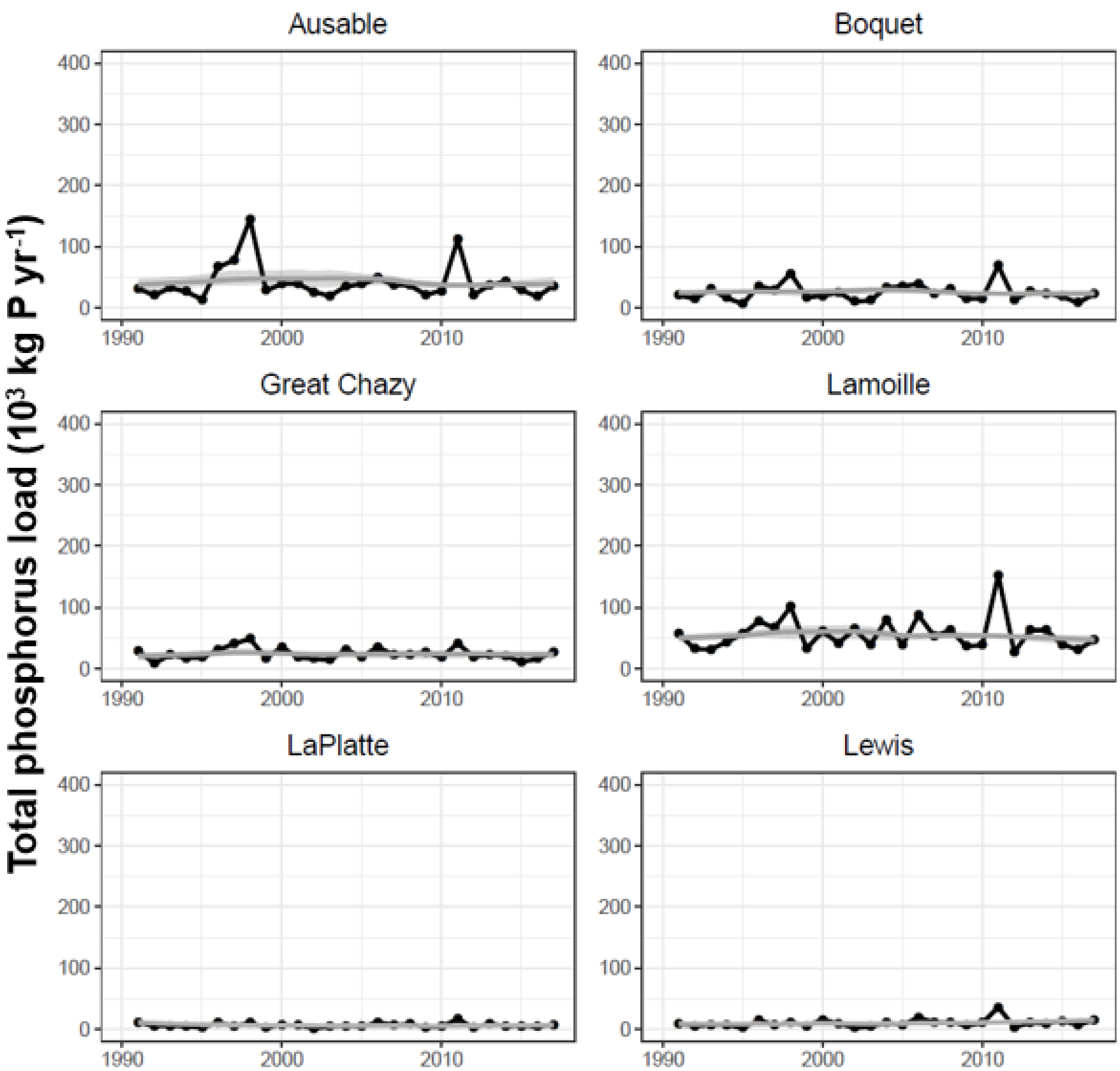
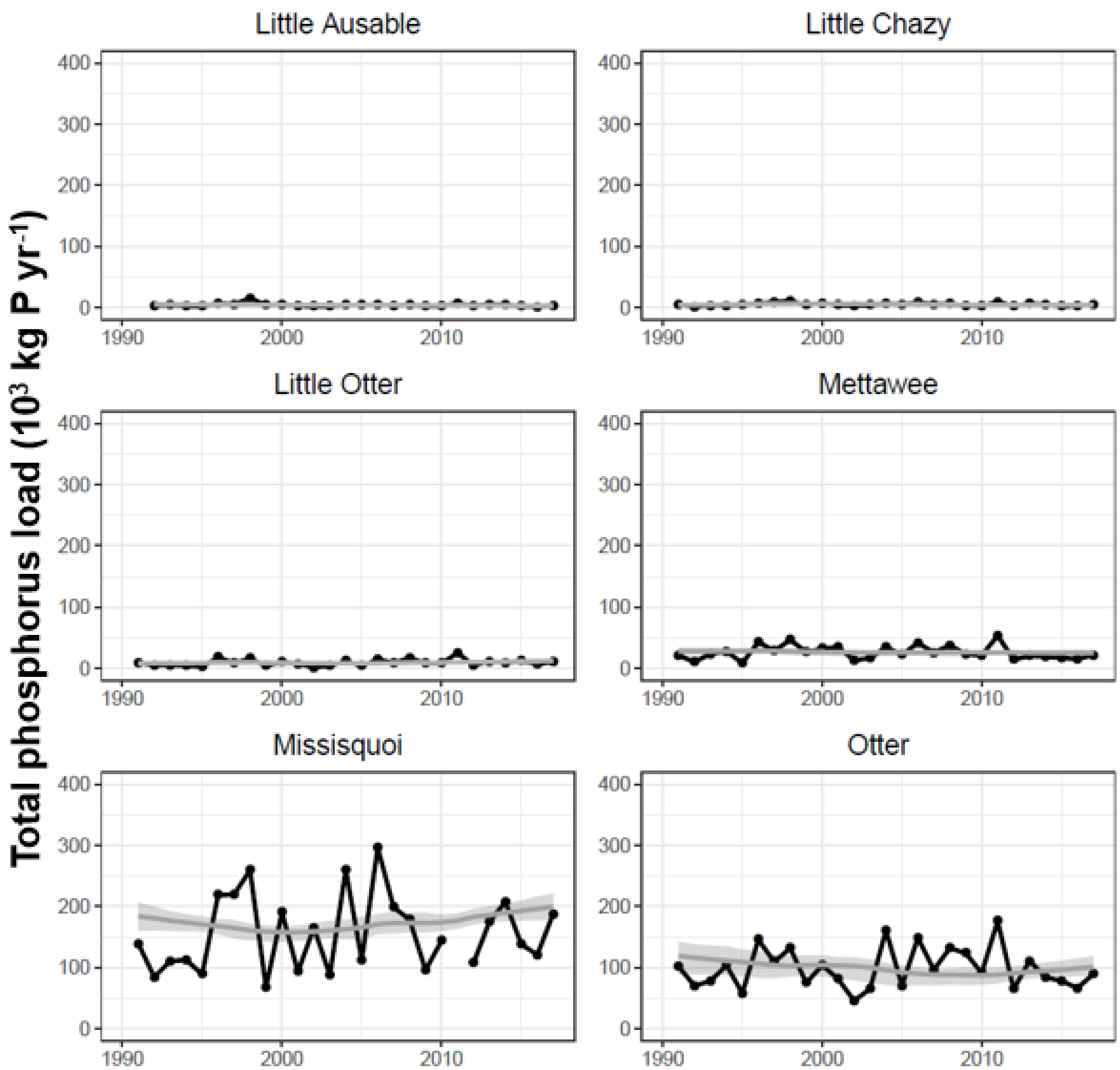


Figure 3. Plot of annual flow-normalized total phosphorus concentration estimates for eighteen Lake Champlain tributaries. The annual flow-normalized concentration is an estimate of the annual mean concentration with the influence of annual water flux variability reduced. Note that the legend is in descending order by the latest value for each tributary.

Table 3. Trend probabilities and magnitudes for **flow-normalized total phosphorus concentration** over three trend periods for eighteen Lake Champlain tributaries. Note that trend periods for (*) Little Ausable River begin as early as 1993, and trend periods for ([a]) Putnam Creek end as late as 2013. Significant trends (probability ≥ 0.90) are outlined and shown in **bold**.

	First half (1991 to 2004)				**Full record (1991 - 2017)**				**Second half (2004 to 2017)**			
Tributary	Direction	Probability of trend	Change (mg L^{-1})	Annualized percent change	Direction	Probability of trend	Change (mg L^{-1})	Annualized percent change	Direction	Probability of trend	Change (mg L^{-1})	Annualized percent change
Ausable	**Increase**	**0.91**	0.005	1.6	No trend	0.62	0.000	0.1	No trend	0.82	-0.005	-1.4
Boquet	No trend	0.89	0.008	2.0	No trend	0.72	0.005	0.6	No trend	0.60	-0.003	-0.6
Great Chazy	**Increase**	**0.95**	0.016	2.6	No trend	0.87	0.025	1.9	No trend	0.65	0.009	1.1
Lamoille	No trend	0.77	0.007	2.0	No trend	0.72	-0.001	-0.1	No trend	0.74	-0.007	-2.2
LaPlatte	**Decrease**	**0.99**	-0.190	-9.8	**Decrease**	**0.99**	-0.190	-5.0	No trend	0.57	0.000	0.0
Lewis	No trend	0.82	0.008	1.4	**Increase**	**0.99**	0.023	1.8	**Increase**	**0.91**	0.015	2.1
Little Ausable*	No trend	0.70	-0.008	-0.9	**Decrease**	**0.97**	-0.028	-1.6	**Decrease**	**0.99**	-0.020	-2.3
Little Chazy	No trend	0.72	0.037	2.7	No trend	0.60	-0.010	-0.4	No trend	0.87	-0.047	-3.5
Little Otter	No trend	0.70	-0.006	-0.4	**Increase**	**0.99**	0.042	1.3	**Increase**	**0.99**	0.047	3.1
Mettawee	No trend	0.62	0.006	0.6	No trend	0.60	-0.001	-0.1	No trend	0.72	-0.007	-0.8
Missisquoi	No trend	0.60	0.003	0.5	**Increase**	**0.90**	0.007	0.5	No trend	0.79	0.003	0.5
Otter	**Decrease**	**0.97**	-0.043	-3.7	**Decrease**	**0.92**	-0.037	-1.5	No trend	0.67	0.007	0.7
Pike	**Decrease**	**0.99**	-0.051	-3.9	**Decrease**	**0.99**	-0.057	-2.3	No trend	0.89	-0.006	-0.7
Poultney	No trend	0.55	0.000	0.0	No trend	0.84	0.011	0.7	No trend	0.88	0.011	1.4
Putnam[a]	No trend	0.50	0.000	0.2	**Increase**	**0.97**	0.011	2.4	**Increase**	**0.99**	0.010	5.7
Salmon	No trend	0.89	0.004	1.3	No trend	0.82	0.004	0.6	No trend	0.57	0.000	-0.1
Saranac	**Increase**	**0.91**	0.003	0.9	No trend	0.72	0.001	0.2	No trend	0.62	-0.002	-0.6
Winooski	No trend	0.82	-0.005	-0.9	No trend	0.60	0.001	0.1	No trend	0.79	0.006	1.1


Ausable
Boquet
Great Chazy
Lamoille
LaPlatte
Lewis
Total phosphorus load (10³ kg P yr⁻¹)
0
100
200
300
400
1990
2000
2010


Little Ausable
Little Chazy
Little Otter
Mettawee
Missisquoi
Otter
Total phosphorus load (10³ kg P yr⁻¹)
0
100
200
300
400
1990
2000
2010

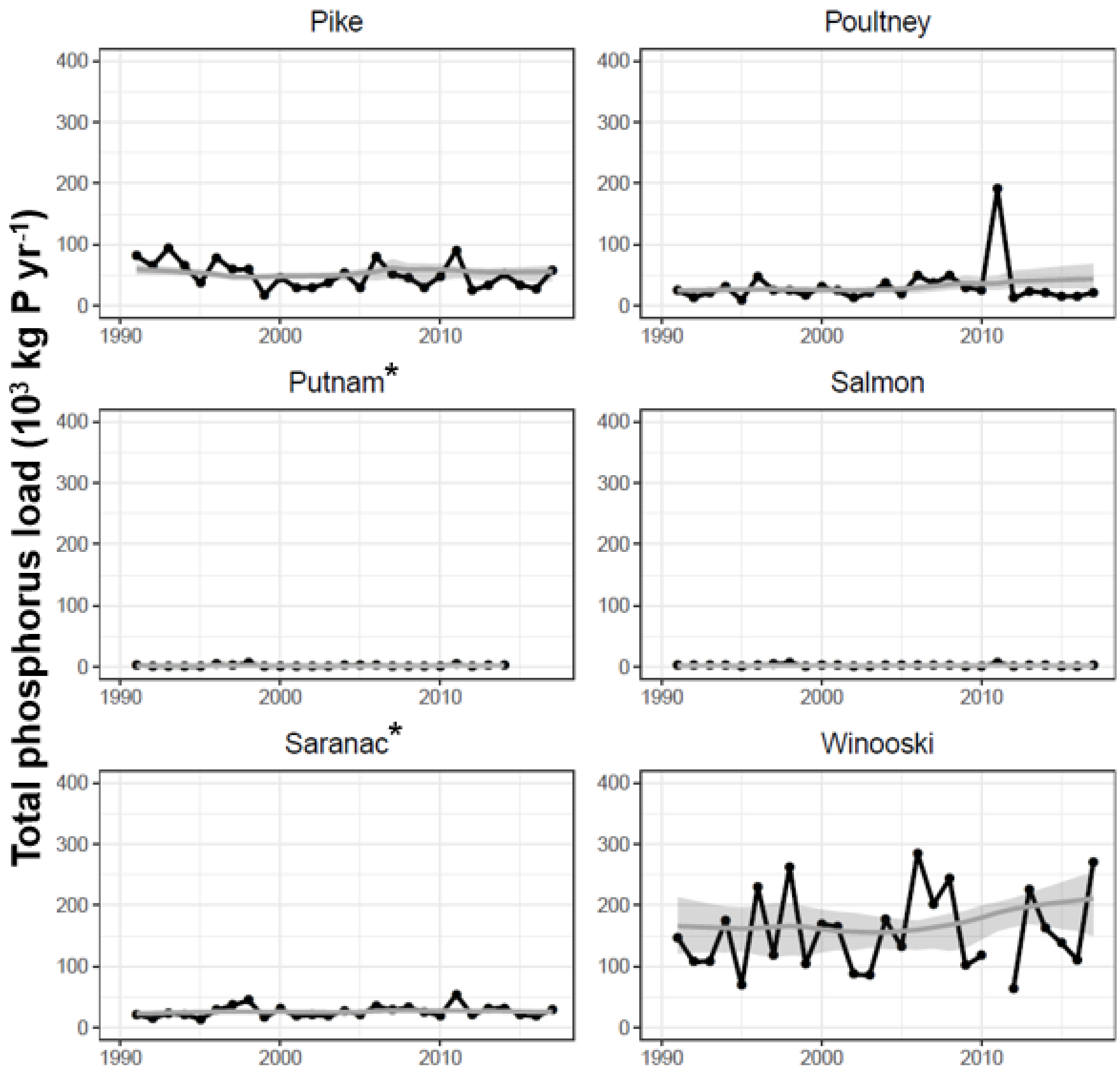


Figure 4. Estimated annual total phosphorus load (black dots and lines) and flow-normalized total phosphorus load (grey lines) with 95% confidence intervals (grey shaded areas) for eighteen Lake Champlain tributaries. An asterisk (*) indicates that the flux bias statistic was outside of the acceptable range and that the results should be interpreted with care.

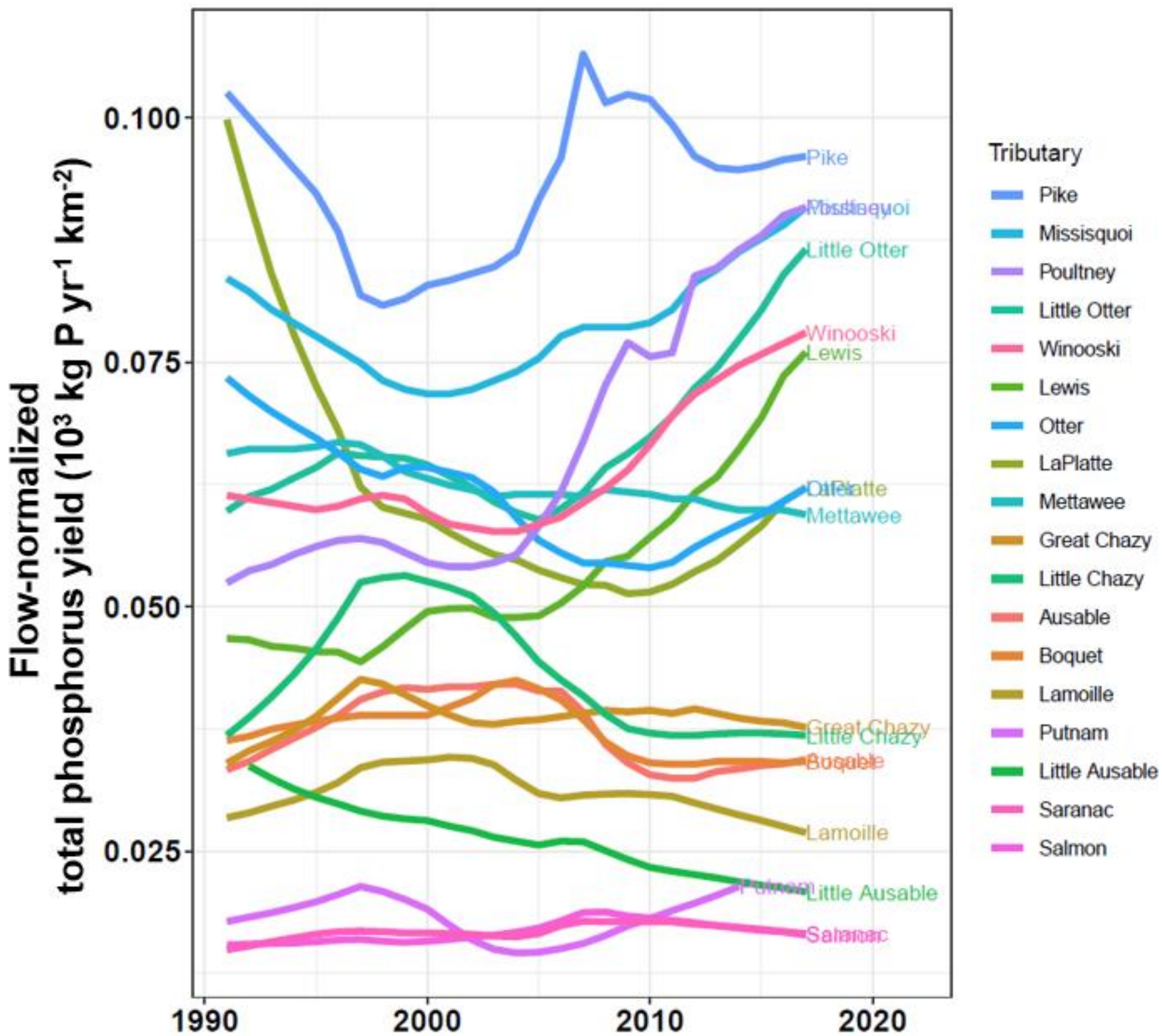


Figure 5. Plot of annual flow-normalized total phosphorus yield estimates for eighteen Lake Champlain tributaries. The flow-normalized yield is an estimate of load per watershed area, with the influence of annual water flux variability reduced. Note that the legend is in descending order by the latest value for each tributary.

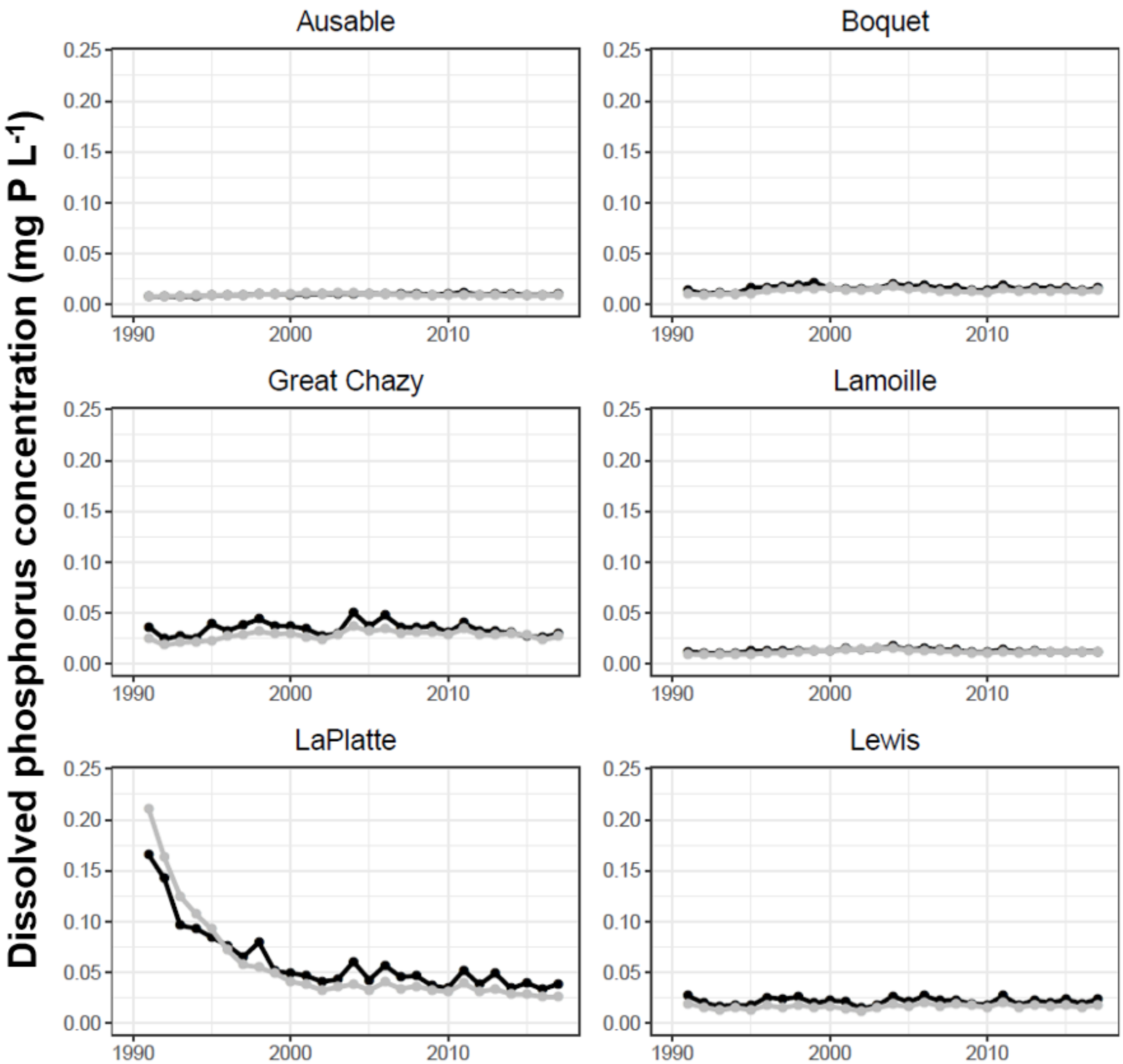
Table 4. Trend probabilities and magnitudes for **flow-normalized total phosphorus load** over three trend periods for eighteen Lake Champlain tributaries. Note that trend periods for (*) Little Ausable River begin as early as 1993, and trend periods for ([a]) Putnam Creek end as late as 2013. Significant trends (probability $\geq$ 0.90) are outlined and shown in **bold**.

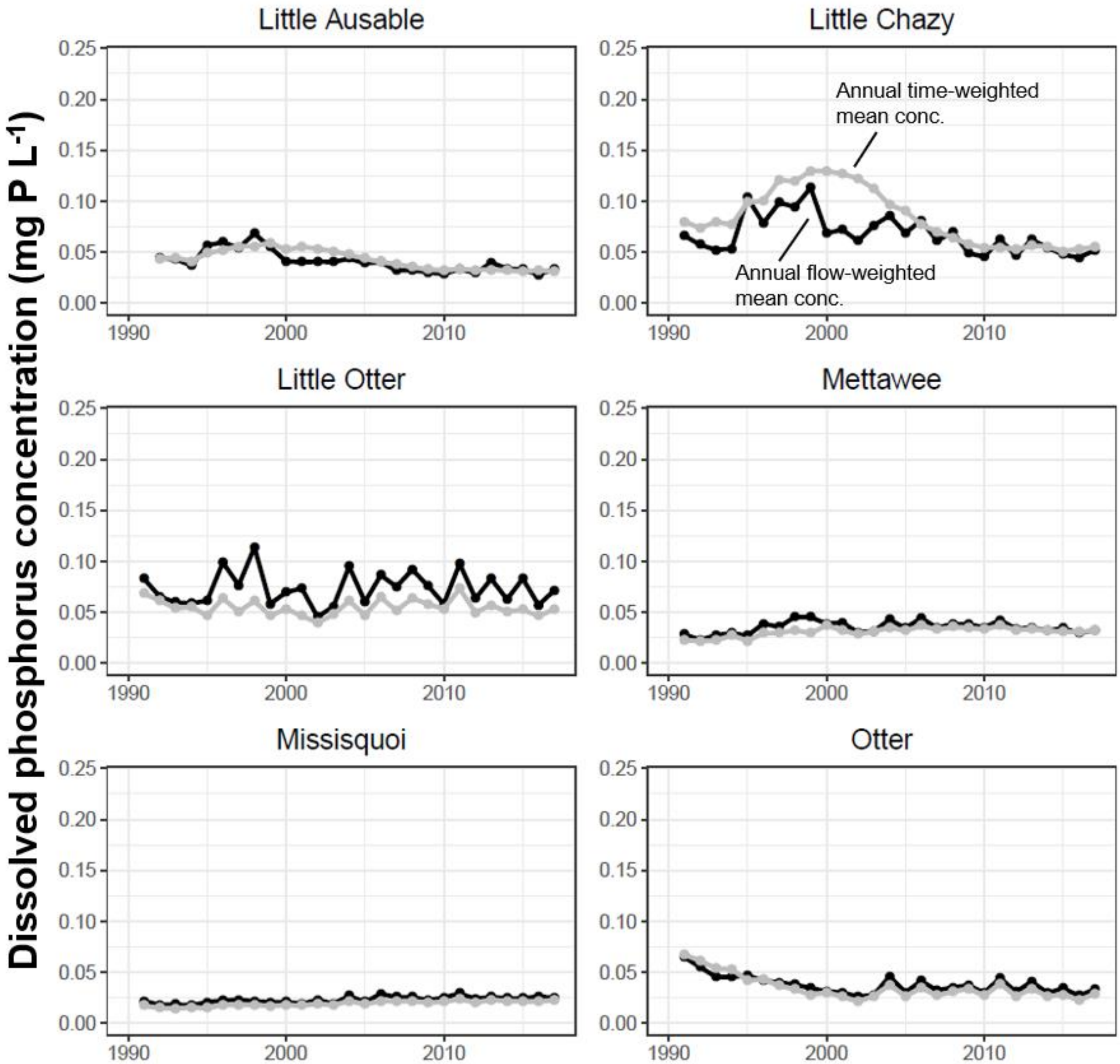
	First half (1991 to 2004)				**Full record (1991 - 2017)**				**Second half (2004 to 2017)**			
Tributary	Direction	Probability of trend	Change (10^3 kg yr^{-1})	Annualized percent change	Direction	Probability of trend	Change (10^3 kg yr^{-1})	Annualized percent change	Direction	Probability of trend	Change (10^3 kg yr^{-1})	Annualized percent change
Ausable	No trend	0.89	10.0	1.8	No trend	0.65	1.1	0.1	No trend	0.70	-9.0	-1.5
Boquet	No trend	0.89	4.3	1.2	No trend	0.60	-1.5	-0.2	No trend	0.89	-5.8	-1.7
Great Chazy	No trend	0.75	2.7	0.9	No trend	0.72	2.3	0.4	No trend	0.65	-0.4	-0.1
Lamoille	No trend	0.82	6.9	1.0	No trend	0.77	-2.6	-0.2	No trend	0.77	-9.5	-1.4
LaPlatte	**Decrease**	**0.99**	-5.2	-4.5	**Decrease**	**0.99**	-4.4	-1.8	No trend	0.79	0.9	0.9
Lewis	No trend	0.70	0.4	0.3	**Increase**	**0.99**	5.9	1.9	**Increase**	**0.97**	5.4	3.4
Little Ausable*	No trend	0.84	-1.4	-2.2	**Decrease**	**0.99**	-2.3	-1.9	**Decrease**	**0.99**	-0.9	-1.7
Little Chazy	No trend	0.70	1.3	1.9	No trend	0.65	0.0	0.0	No trend	0.84	-1.3	-1.9
Little Otter	No trend	0.60	0.0	0.0	**Increase**	**0.99**	4.0	1.4	**Increase**	**0.99**	4.0	2.9
Mettawee	No trend	0.55	-1.8	-0.5	No trend	0.70	-2.7	-0.4	No trend	0.60	-0.9	-0.3
Missisquoi	No trend	0.87	-21.0	-0.9	No trend	0.86	15.0	0.3	**Increase**	**0.99**	36.0	1.5
Otter	No trend	0.82	-23.0	-1.7	No trend	0.70	-18.0	-0.6	No trend	0.70	5.1	0.4
Pike	**Decrease**	**0.91**	-9.5	-1.3	No trend	0.72	-3.7	-0.2	No trend	0.72	5.7	0.8
Poultney	No trend	0.62	1.5	0.4	No trend	0.89	19.0	2.2	**Increase**	**0.97**	17.0	3.9
Putnam[a]	No trend	0.60	-0.4	-1.5	No trend	0.60	0.4	0.6	**Increase**	**0.97**	0.8	3.9
Salmon	No trend	0.74	0.2	0.6	No trend	0.72	0.2	0.2	No trend	0.62	-0.1	-0.1
Saranac	No trend	0.86	2.2	0.7	No trend	0.87	2.7	0.4	No trend	0.57	0.5	0.2
Winooski	No trend	0.65	-10.0	-0.5	No trend	0.82	44.0	0.9	No trend	0.87	54.0	2.3

Dissolved phosphorus

Dissolved phosphorus concentrations were generally highest in Little Otter Creek, and the Pike and Little Chazy Rivers, and were similar and relatively lower for several tributaries (Figure *6* and Figure *7*). For 7 out of 18 tributaries, no trends in flow-normalized dissolved phosphorus concentration were found for any of the three trend periods (Table *5*). Flow-normalized concentration decreased in the Otter Creek and the LaPlatte River for the first half and full record trend periods, but these trends were not found in the second half of record. Conversely, flow-normalized concentration significantly decreased in the Little Ausable River for the second half of the record only. The Pike River showed significant flow-normalized concentration decreases for full record and second half trend periods. Full record significant increases in flow-normalized concentration were observed in the Mettawee, Missisquoi, and Saranac Rivers and Putnam Creek. Only Putnam Creek showed a significant increase in the second half of record.

Dissolved phosphorus loads were highest at Otter Creek and Missisquoi River, where loads were often above 40 metric tons of dissolved phosphorus per year (Figure *8*). Dissolved phosphorus yields were relatively high for Little Otter Creek, and the Pike and Little Chazy Rivers (Figure *9*). Seven out of the eighteen tributaries showed no trend in flow-normalized dissolved phosphorus load for any of the three trend periods considered (Table 6). The LaPlatte River was the only tributary to demonstrate a significant decrease in flow-normalized load for all three trend periods, and the Otter Creek and Winooski River showed a significant decrease for the first half of the record, but no trends for the second half. Significant increases in flow-normalized load were observed for several tributaries for the first half and full record trend periods, including: Ausable, Boquet, Salmon, and Saranac Rivers and Putnam Creek. Of these, only the Putnam Creek continued to increase in flow-normalized load in the second half of record; no trend was observed for all others.


Dissolved phosphorus concentration (mg P L-1)
Ausable
Boquet
Great Chazy
Lamoille
LaPlatte
Lewis
0.25
0.20
0.15
0.10
0.05
0.00
1990
2000
2010


Dissolved phosphorus concentration (mg P L-1)
Little Ausable
Little Chazy
Annual time-weighted mean conc.
Annual flow-weighted mean conc.
Little Otter
Mettawee
Missisquoi
Otter
0.25
0.20
0.15
0.10
0.05
0.00
1990
2000
2010

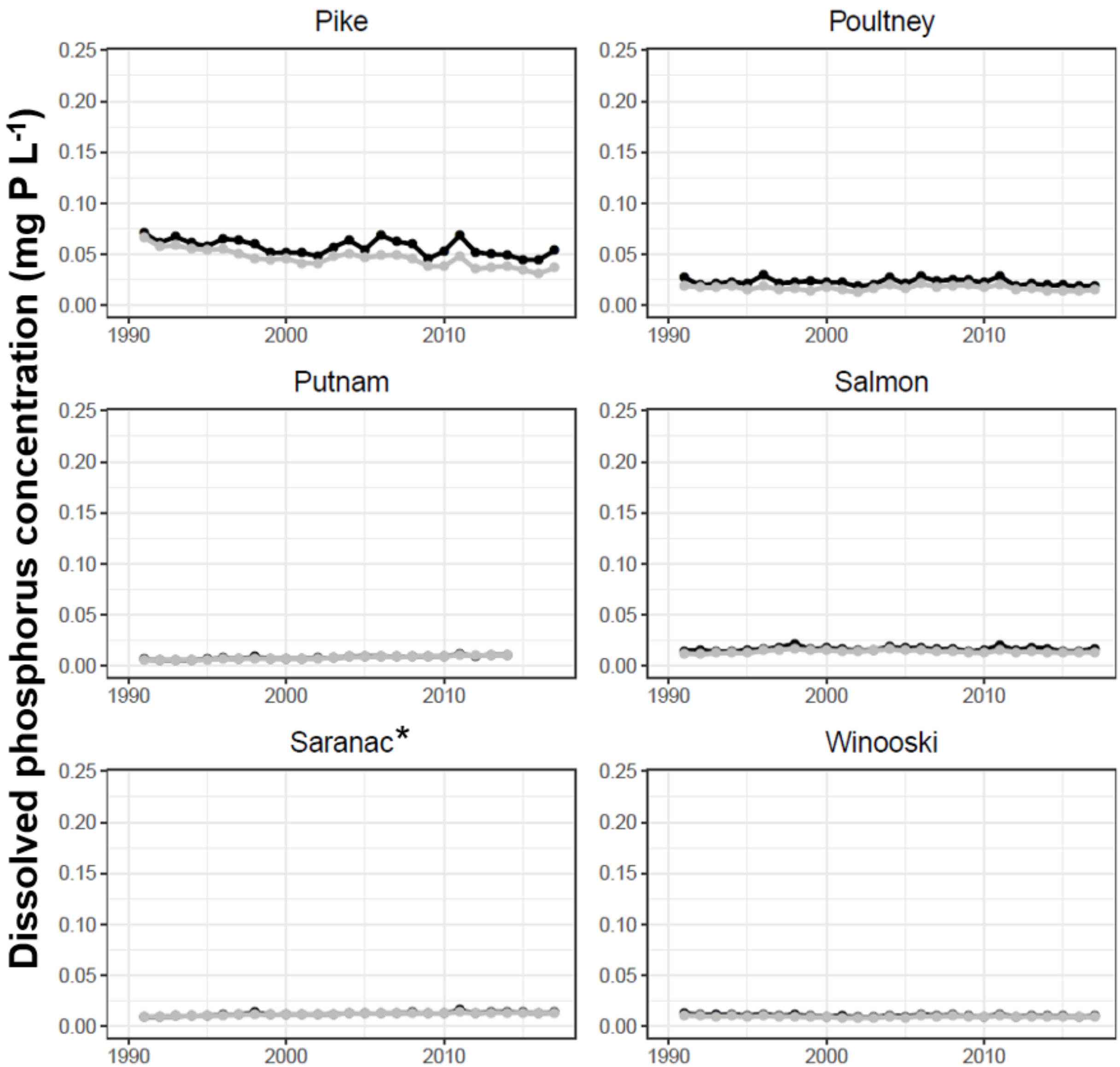


Figure 6. Estimated annual flow-weighted mean (black dots and lines) and time-weighted mean (grey dots and lines) dissolved phosphorus concentrations for eighteen Lake Champlain tributaries. An asterisk (*) indicates that the flux bias statistic was outside of the acceptable range and that the results should be interpreted with care.

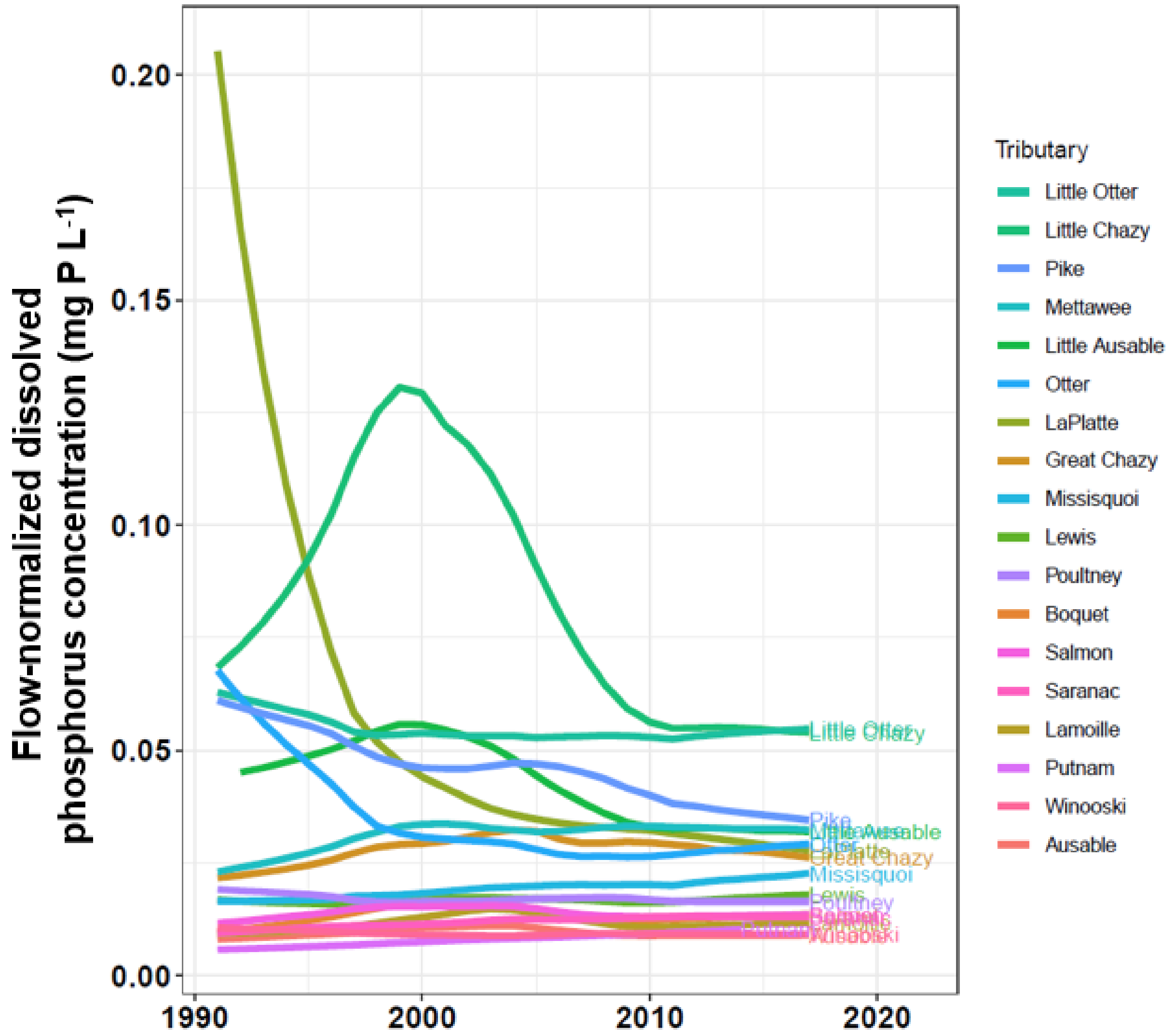
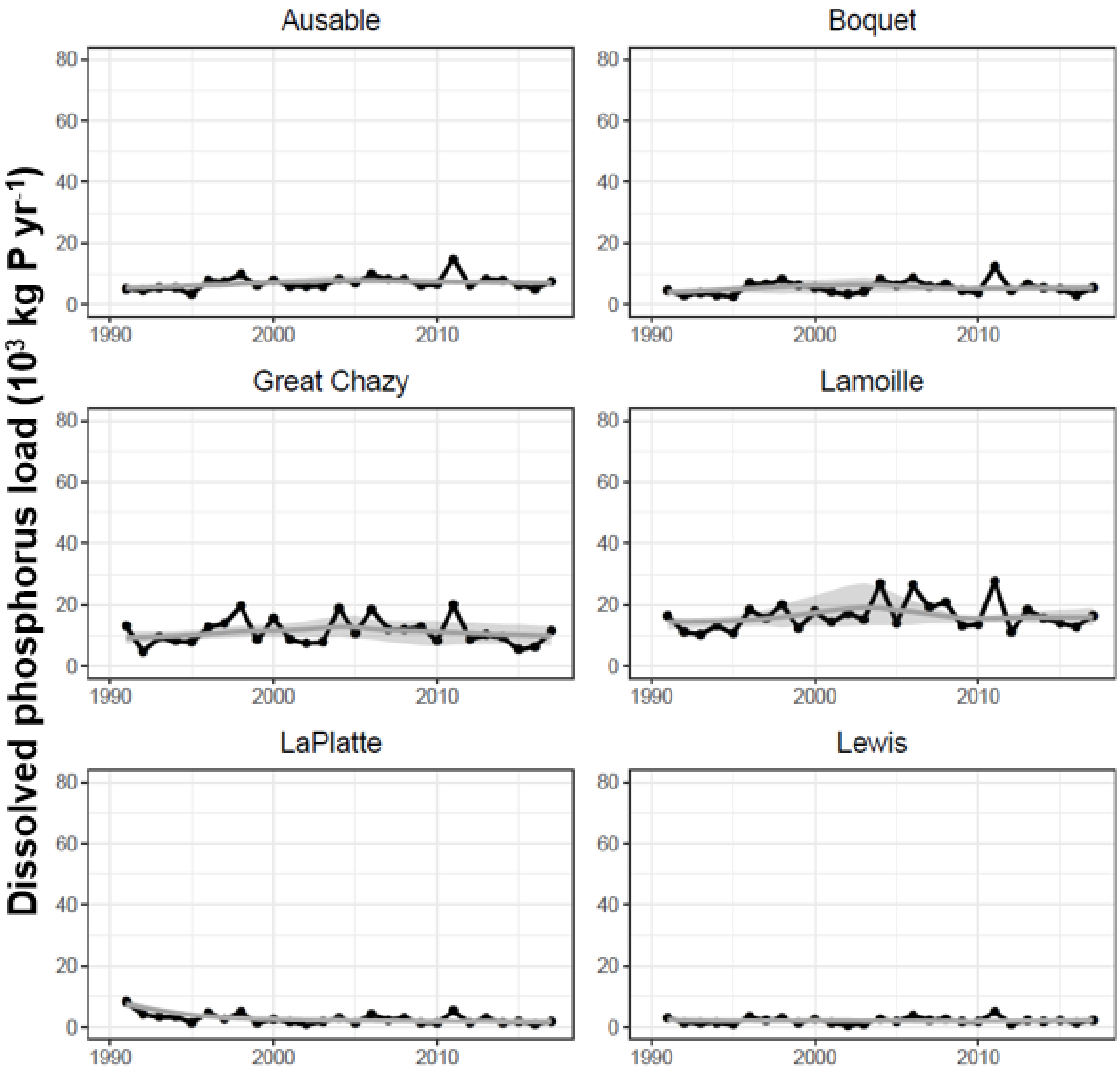
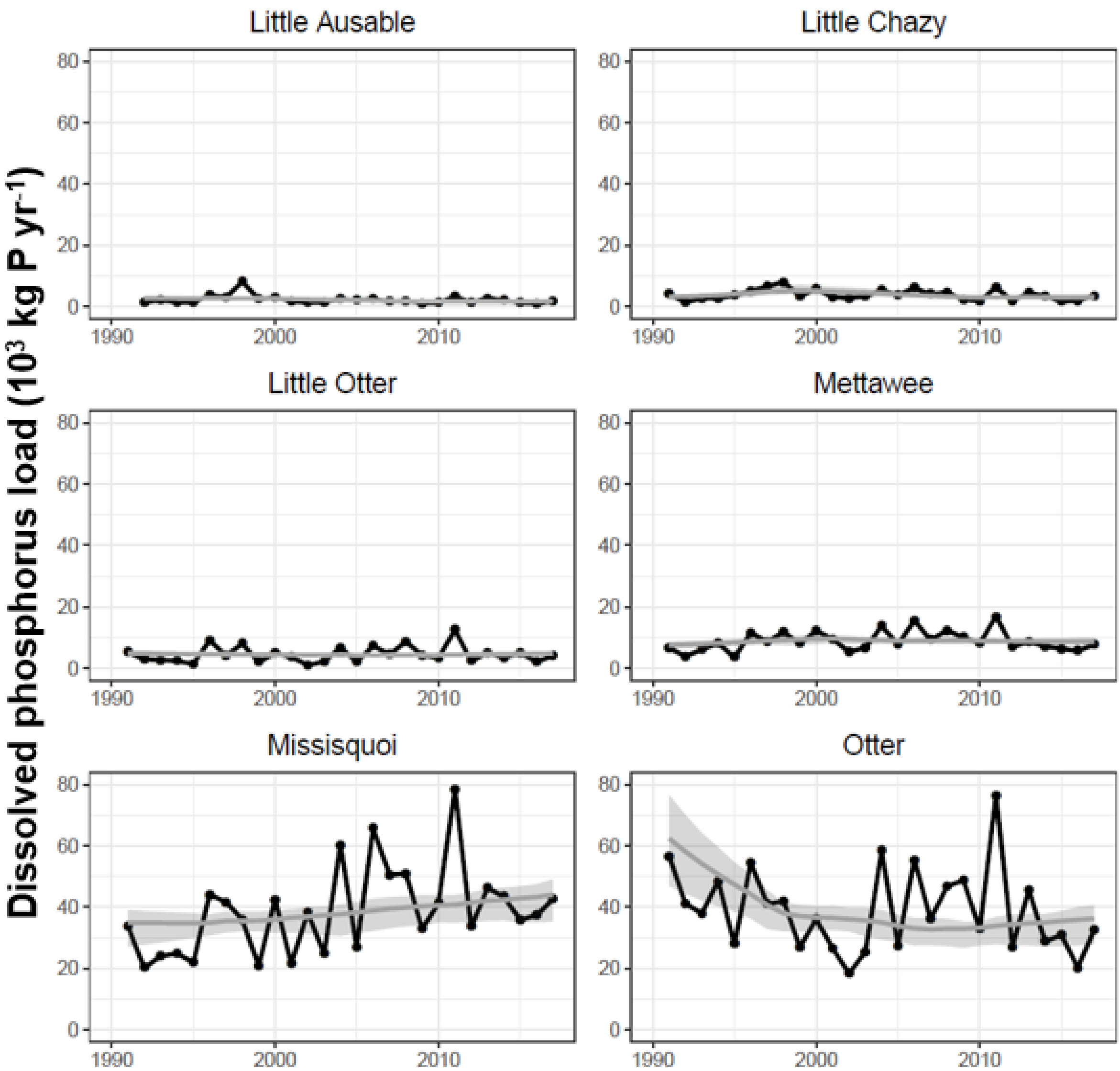


Figure 7. Plot of annual flow-normalized dissolved phosphorus concentration estimates for eighteen Lake Champlain tributaries. The annual flow-normalized concentration is an estimate of the annual mean concentration with the influence of annual water flux variability reduced. Note that the legend is in descending order by the latest value for each tributary.

Table 5. Trend probabilities and magnitudes for **flow-normalized dissolved phosphorus concentration** over three trend periods for eighteen Lake Champlain tributaries. Note that trend periods for (*) Little Ausable River begin as early as 1993, and trend periods for ([a]) Putnam Creek end as late as 2013. Significant trends (probability ≥ 0.90) are outlined and shown in **bold**.

	First half (1991 to 2004)				**Full record (1991 - 2017)**				**Second half (2004 to 2017)**			
Tributary	Direction	Probability of trend	Change (mg L^{-1})	Annualized percent change	Direction	Probability of trend	Change (mg L^{-1})	Annualized percent change	Direction	Probability of trend	Change (mg L^{-1})	Annualized percent change
Ausable	**Increase**	**0.96**	0.0030	2.5	No trend	0.84	0.0009	0.4	No trend	0.84	-0.0021	-1.6
Boquet	No trend	0.88	0.0061	3.8	No trend	0.86	0.0040	1.3	No trend	0.55	-0.0022	-1.2
Great Chazy	No trend	0.77	0.0110	3.1	No trend	0.60	0.0045	0.7	No trend	0.79	-0.0061	-1.6
Lamoille	**Increase**	**0.91**	0.0053	3.5	No trend	0.89	0.0024	0.9	No trend	0.60	-0.0029	-1.7
LaPlatte	**Decrease**	**0.99**	-0.1700	-12.7	**Decrease**	**0.99**	-0.1800	-7.3	No trend	0.89	-0.0078	-1.9
Lewis	No trend	0.57	0.0003	0.1	No trend	0.77	0.0012	0.3	No trend	0.65	0.0009	0.4
Little Ausable*	No trend	0.84	0.0030	0.5	No trend	0.87	-0.0130	-1.4	**Decrease**	**0.99**	-0.0160	-3.1
Little Chazy	No trend	0.89	0.0340	3.1	No trend	0.57	-0.0140	-0.9	No trend	0.82	-0.0480	-4.8
Little Otter	No trend	0.82	-0.0097	-1.2	No trend	0.90	-0.0081	-0.5	No trend	0.67	0.0016	0.2
Mettawee	**Increase**	**0.99**	0.0092	2.6	**Increase**	**0.97**	0.0094	1.3	No trend	0.50	0.0002	0.0
Missisquoi	**Increase**	**0.94**	0.0032	1.4	**Increase**	**0.90**	0.0063	1.2	No trend	0.87	0.0031	1.1
Otter	**Decrease**	**1.00**	-0.0380	-6.3	**Decrease**	**0.99**	-0.0380	-3.2	No trend	0.52	0.0001	0.0
Pike	No trend	0.84	-0.0140	-2.0	**Decrease**	**0.99**	-0.0270	-2.1	**Decrease**	**0.97**	-0.0130	-2.4
Poultney	No trend	0.57	-0.0023	-1.0	No trend	0.67	-0.0027	-0.6	No trend	0.62	-0.0004	-0.2
Putnam[a]	**Increase**	**0.97**	0.0025	2.8	**Increase**	**0.99**	0.0043	2.5	**Increase**	**0.99**	0.0017	2.1
Salmon	**Increase**	**0.99**	0.0038	2.2	No trend	0.89	0.0018	0.6	No trend	0.74	-0.0019	-1.1
Saranac	**Increase**	**0.99**	0.0031	2.2	**Increase**	**0.99**	0.0036	1.2	No trend	0.67	0.0005	0.3
Winooski	No trend	0.86	-0.0018	-1.4	No trend	0.90	-0.0015	-0.6	No trend	0.60	0.0003	0.3


Dissolved phosphorus load (10^3 kg P yr^{-1})
Ausable
Boquet
Great Chazy
Lamoille
LaPlatte
Lewis
0
20
40
60
80
1990
2000
2010


Little Ausable
Little Chazy
Little Otter
Mettawee
Missisquoi
Otter
Dissolved phosphorus load (10^3 kg P yr^{-1})
0
20
40
60
80
1990
2000
2010

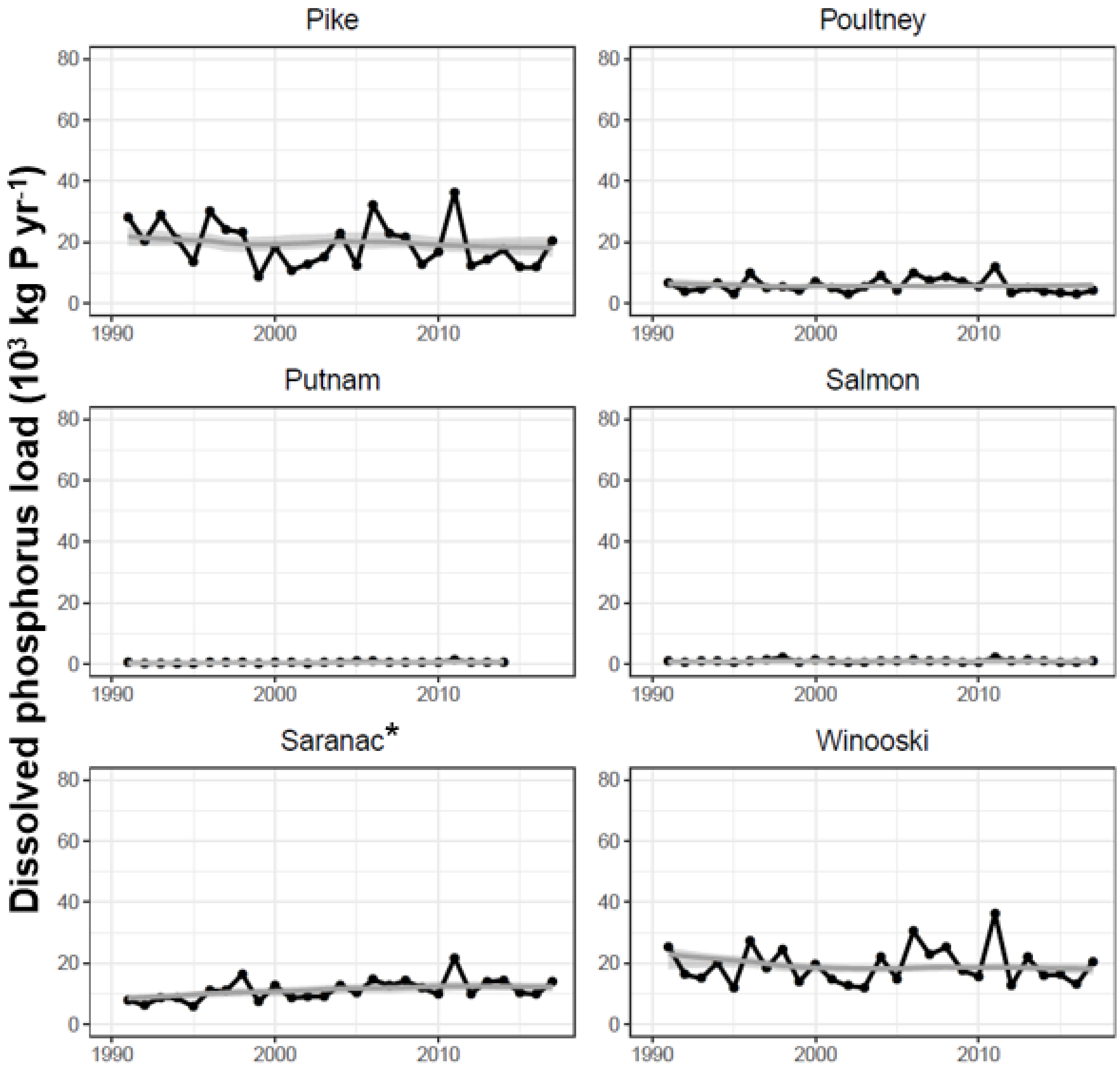


Figure 8. Estimated annual dissolved phosphorus load (black dots and lines) and flow-normalized dissolved phosphorus load (grey lines) with 95% confidence intervals (grey shaded areas) for eighteen Lake Champlain tributaries. An asterisk (*) indicates that the flux bias statistic was outside of the acceptable range and that the results should be interpreted with care.

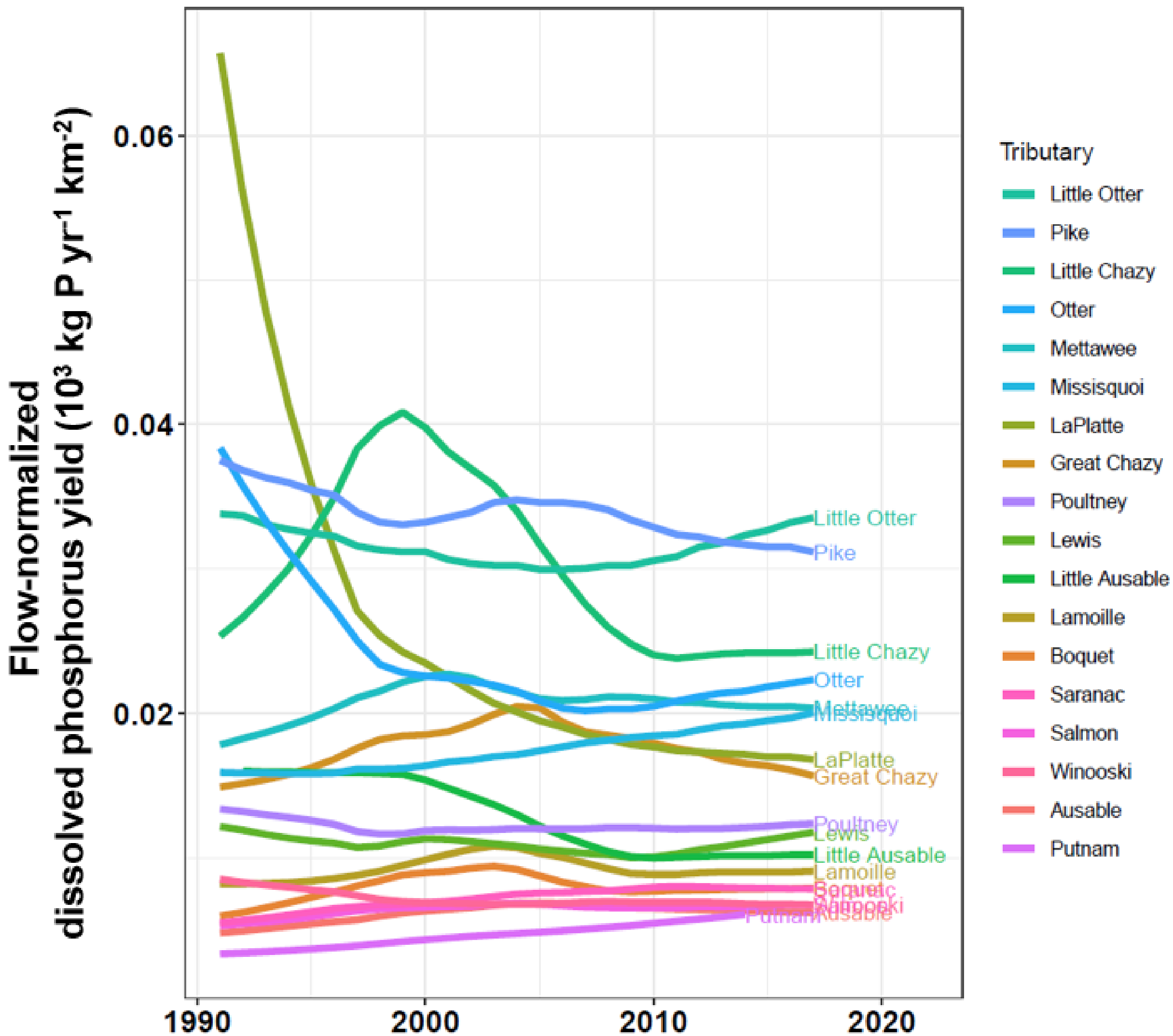


Figure 9. Plot of annual flow-normalized dissolved phosphorus yield estimates for eighteen Lake Champlain tributaries. The flow-normalized yield is an estimate of load per watershed area, with the influence of annual water flux variability reduced. Note that the legend is in descending order by the latest value for each tributary.

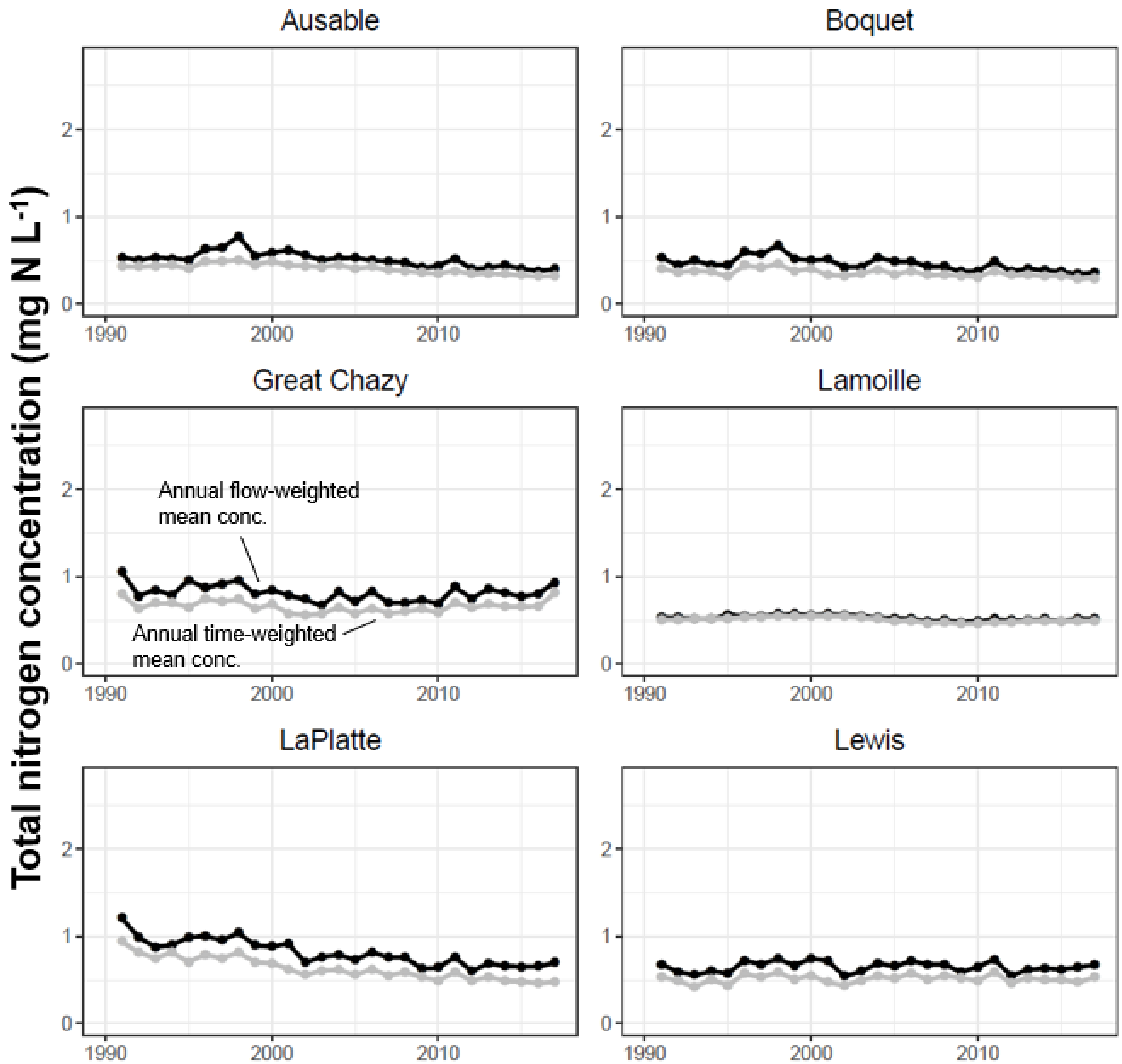
Table 6. Trend probabilities and magnitudes for **flow-normalized dissolved phosphorus load** over three trend periods for eighteen Lake Champlain tributaries. Note that trend periods for (*) Little Ausable River begin as early as 1993, and trend periods for ([a]) Putnam Creek end as late as 2013. Significant trends (probability ≥ 0.90) are outlined and shown in **bold**.

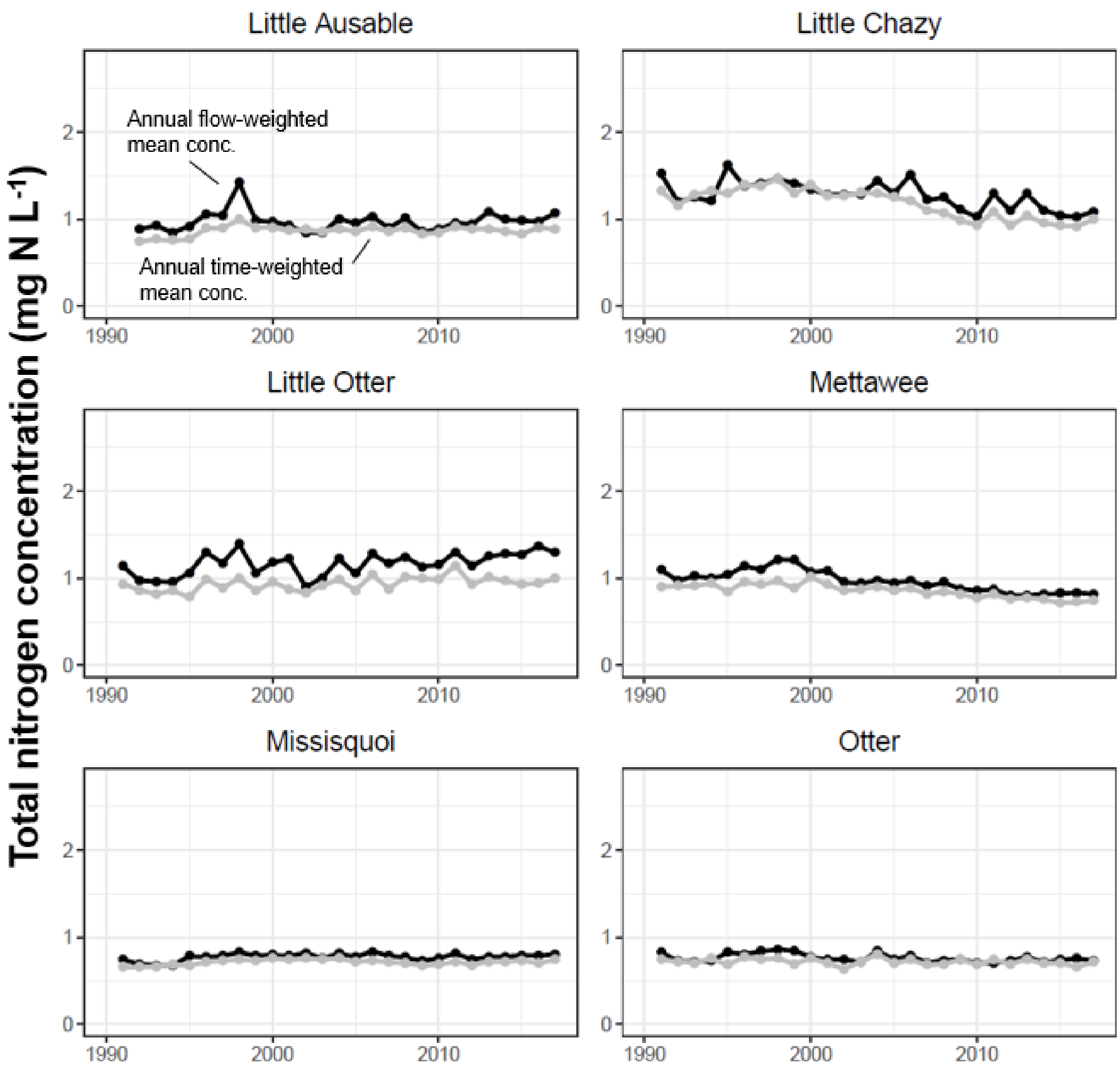
	First half (1991 to 2004)				Full record (1991 - 2017)				Second half (2004 to 2017)			
Tributary	Direction	Probability of trend	Change (10^3 kg yr^{-1})	Annualized percent change	Direction	Probability of trend	Change (10^3 kg yr^{-1})	Annualized percent change	Direction	Probability of trend	Change (10^3 kg yr^{-1})	Annualized percent change
Ausable	**Increase**	**1.00**	2.4	2.8	**Increase**	**0.97**	1.6	1.0	No trend	0.84	-0.8	-0.8
Boquet	**Increase**	**0.91**	2.3	3.4	**Increase**	**0.91**	1.4	1.1	No trend	0.67	-0.9	-1.2
Great Chazy	No trend	0.84	3.5	2.5	No trend	0.57	0.5	0.2	No trend	0.87	-3.0	-2.0
Lamoille	No trend	0.84	4.5	2.1	No trend	0.79	1.5	0.4	No trend	0.67	-3.0	-1.3
LaPlatte	**Decrease**	**0.99**	-5.3	-8.6	**Decrease**	**0.99**	-5.7	-5.0	**Decrease**	**0.99**	-0.4	-1.4
Lewis	No trend	0.74	-0.3	-0.9	No trend	0.52	-0.1	-0.1	No trend	0.82	0.2	0.7
Little Ausable*	No trend	0.65	-0.5	-1.7	No trend	0.84	-1.0	-1.8	No trend	0.89	-0.5	-1.8
Little Chazy	**Increase**	**0.95**	1.1	2.3	No trend	0.70	-0.1	-0.2	No trend	0.89	-1.3	-2.6
Little Otter	No trend	0.87	-0.5	-0.9	No trend	0.50	0.0	0.0	No trend	0.89	0.5	0.8
Mettawee	**Increase**	**0.99**	1.6	1.4	No trend	0.81	1.1	0.5	No trend	0.70	-0.5	-0.4
Missisquoi	No trend	0.86	2.7	0.6	**Increase**	**0.90**	9.0	0.9	No trend	0.89	6.3	1.2
Otter	**Decrease**	**0.96**	-27.0	-4.4	**Decrease**	**0.99**	-26.0	-2.1	No trend	0.57	1.3	0.3
Pike	No trend	0.57	-1.5	-0.6	No trend	0.89	-3.6	-0.7	No trend	0.86	-2.1	-0.8
Poultney	No trend	0.60	-0.7	-0.8	No trend	0.62	-0.5	-0.3	No trend	0.55	0.2	0.2
Putnam[a]	**Increase**	**0.99**	0.2	2.7	**Increase**	**0.99**	0.3	2.6	**Increase**	**0.99**	0.2	2.4
Salmon	**Increase**	**0.99**	0.3	2.0	**Increase**	**0.94**	0.2	0.9	No trend	0.55	0.0	-0.1
Saranac	**Increase**	**0.97**	3.1	2.4	**Increase**	**0.99**	3.7	1.4	No trend	0.72	0.6	0.4
Winooski	**Decrease**	**0.90**	-4.7	-1.8	**Decrease**	**0.97**	-4.8	-0.9	No trend	0.57	-0.1	0.0

Total nitrogen

In general, the highest annual mean total nitrogen concentrations were observed at the Pike River, and the lowest concentrations were observed at the Putnam Creek (Figure 10 and Figure *11*). Although 8 of the 18 tributaries demonstrated no trend in flow-normalized concentration over any of the three trend periods, nine tributaries showed decreasing trends in flow-normalized concentration for at least one trend period (Table *7*). Significant full record flow-normalized concentration decreases were found for seven tributaries: Ausable, LaPlatte, Little Chazy, Mettawee, Salmon, and Saranac Rivers and Putnam Creek. Pike River demonstrated the only full record significant increase in flow-normalized concentration, though no trend was observed in the second half of record. The Winooski River demonstrated a significant increase in flow-normalized concentration for the first half of record and a significant decrease in the second half of record, resulting in no significant full record trend.

Although Lake Champlain's largest tributaries, the Winooski and Missisquoi Rivers, generally had the highest annual total nitrogen loads, the Pike River annual flow-normalized total nitrogen yield often exceeded that of other tributaries by a factor of two (Figure *13*). Flow-normalized total nitrogen yield was lowest in the Salmon and Boquet Rivers and Putnam Creek. Trends in flow-normalized load were found for at least one trend period for all but four tributaries (Table *8*). Six tributaries decreased in flow-normalized total nitrogen load for the full record trend period: the LaPlatte, Mettawee, Saranac, and Salmon Rivers, and Otter and Putnam Creeks. Several tributaries had trends that changed from the first half of the record to the second half. The Ausable, Boquet, Little Chazy, and Mettawee Rivers showed no trend for the first half of record, then had significant decreases in the second half of the record. The Winooski River demonstrated a significant increase in flow-normalized load for the first half of record and a significant decrease in the second half of record, resulting in no significant full record trend. In addition, full record significant increases in flow-normalized load were found in the Little Otter Creek (increased full record and second half only), Pike River (increased first half and full record only), Great Chazy River (increased second half only), and Missisquoi River (increased first half of record only).


Total nitrogen concentration (mg N L-1)
Ausable
Boquet
Great Chazy
Lamoille
LaPlatte
Lewis
Annual flow-weighted mean conc.
Annual time-weighted mean conc.
0
1
2
1990
2000
2010


Total nitrogen concentration (mg N L-1)
Little Ausable
Little Chazy
Little Otter
Mettawee
Missisquoi
Otter
Annual flow-weighted mean conc.
Annual time-weighted mean conc.
0
1
2
1990
2000
2010

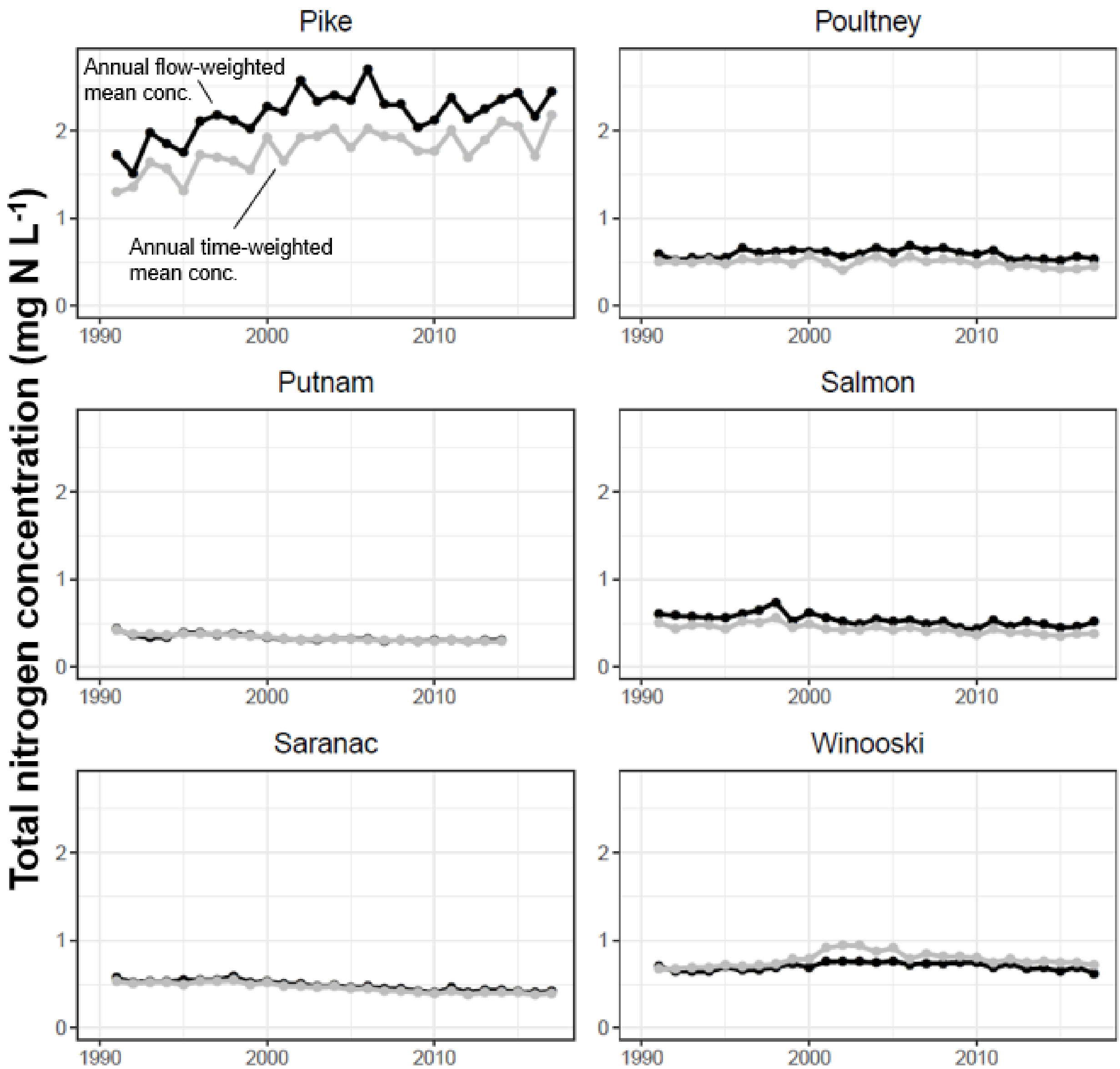


Figure 10. Estimated annual flow-weighted mean (black dots and lines) and time-weighted mean (grey dots and lines) total nitrogen concentrations for eighteen Lake Champlain tributaries.

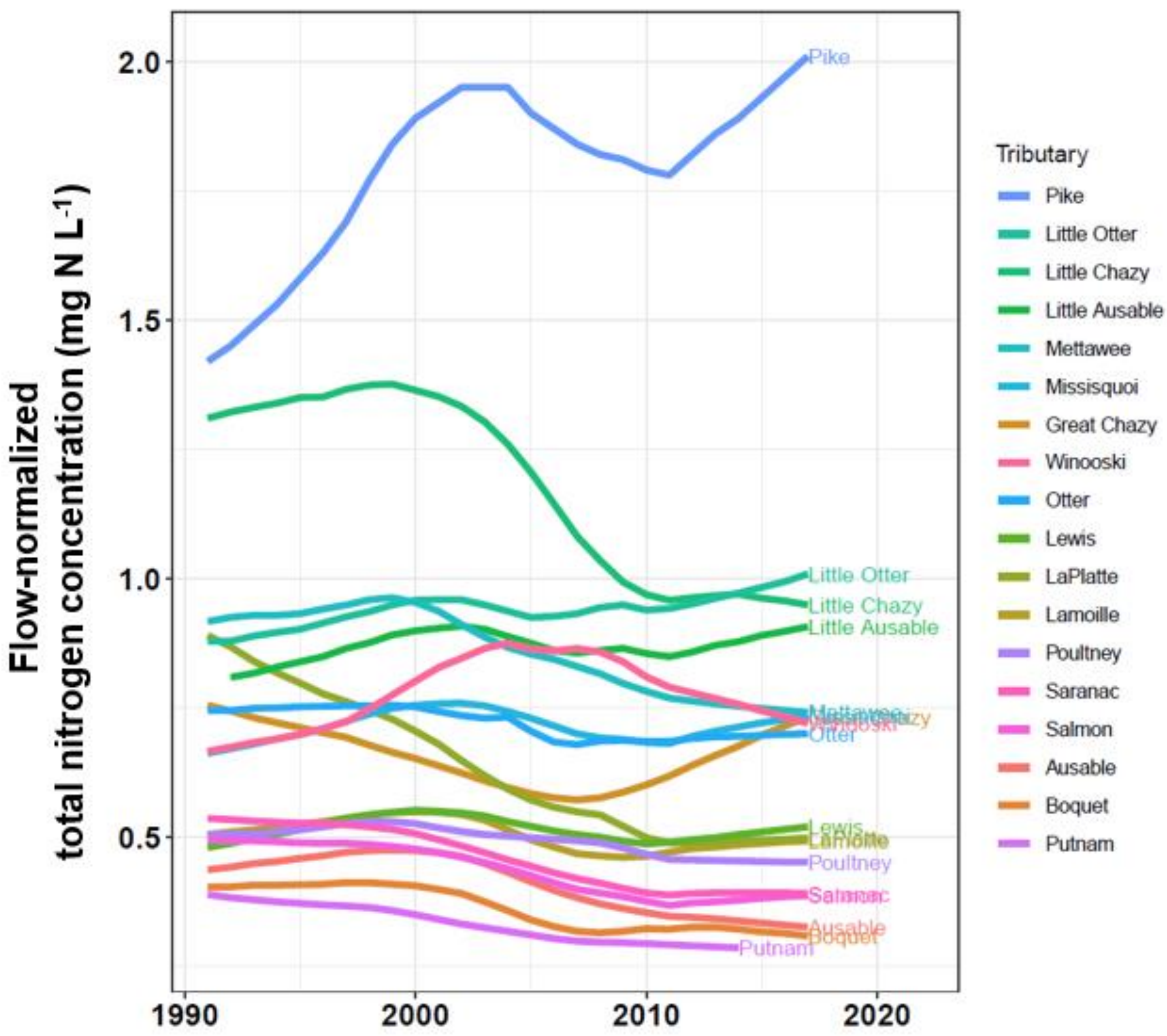
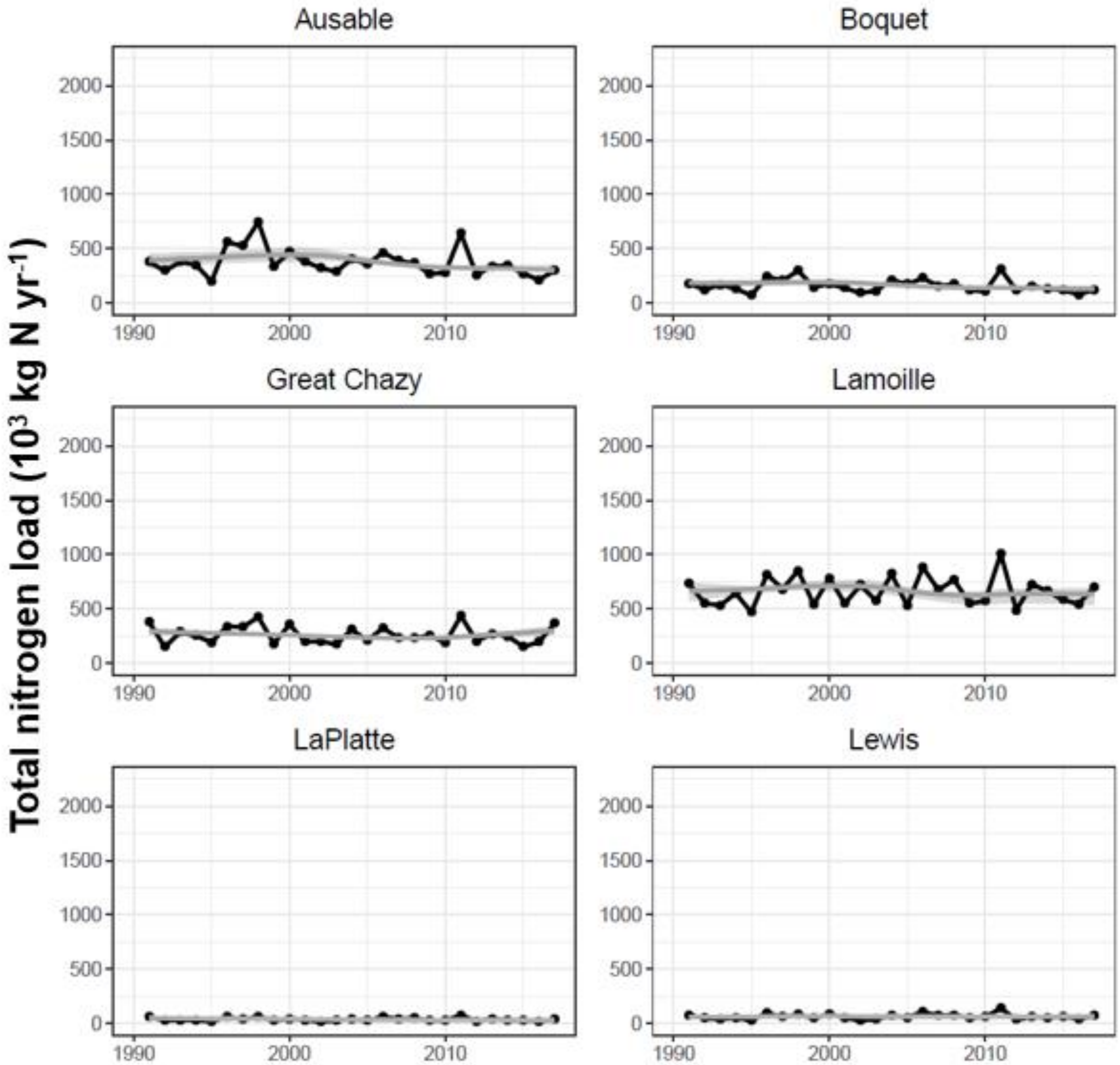
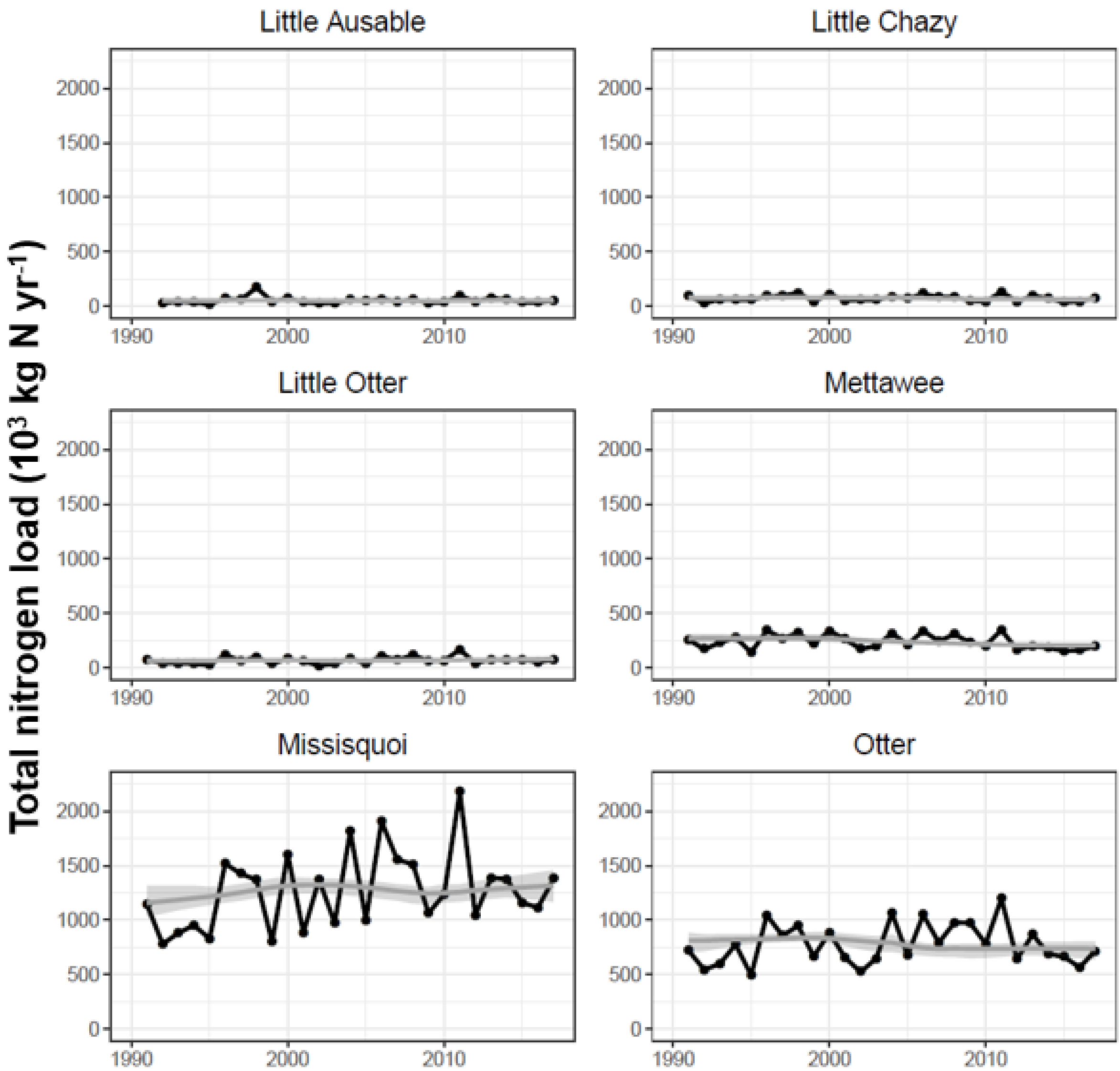


Figure 11. Plot of annual flow-normalized total nitrogen concentration estimates for eighteen Lake Champlain tributaries. The annual flow-normalized concentration is an estimate of the annual mean concentration with the influence of annual water flux variability reduced. Note that the legend is in descending order by the latest value for each tributary.

Table 7. Trend probabilities and magnitudes for **flow-normalized total nitrogen concentration** over three trend periods for eighteen Lake Champlain tributaries. Note that trend periods for ([a]) Putnam Creek end as late as 2013. Significant trends (probability ≥ 0.90) are outlined and shown in **bold**.

	First half (1993 to 2004)				Full record (1993 - 2017)				Second half (2004 to 2017)			
Tributary	Direction	Probability of trend	Change (mg L^{-1})	Annualized percent change	Direction	Probability of trend	Change (mg L^{-1})	Annualized percent change	Direction	Probability of trend	Change (mg L^{-1})	Annualized percent change
Ausable	No trend	0.57	-0.02	-0.4	**Decrease**	**0.97**	-0.12	-1.3	**Decrease**	**0.99**	-0.11	-2.1
Boquet	No trend	0.89	-0.05	-1.2	No trend	0.87	-0.10	-1.1	No trend	0.74	-0.05	-1.2
Great Chazy	**Decrease**	**0.99**	-0.14	-1.9	No trend	0.52	0.00	0.0	No trend	0.88	0.14	1.6
Lamoille	No trend	0.60	0.00	0.0	No trend	0.50	-0.02	-0.2	No trend	0.65	-0.02	-0.3
LaPlatte	**Decrease**	**0.97**	-0.25	-3.1	**Decrease**	**0.97**	-0.34	-2.2	**Decrease**	**0.91**	-0.10	-1.3
Lewis	No trend	0.70	0.03	0.6	No trend	0.74	0.02	0.2	No trend	0.57	-0.01	-0.2
Little Ausable	No trend	0.84	0.07	0.8	No trend	0.87	0.09	0.4	No trend	0.60	0.02	0.2
Little Chazy	No trend	0.65	-0.07	-0.5	**Decrease**	**0.93**	-0.38	-1.4	No trend	0.86	-0.31	-2.2
Little Otter	No trend	0.62	0.05	0.5	No trend	0.87	0.12	0.5	No trend	0.72	0.07	0.6
Mettawee	No trend	0.62	-0.06	-0.6	**Decrease**	**0.97**	-0.19	-0.9	**Decrease**	**0.99**	-0.13	-1.2
Missisquoi	No trend	0.76	0.06	0.8	No trend	0.89	0.06	0.3	No trend	0.62	-0.01	-0.1
Otter	No trend	0.70	-0.02	-0.2	No trend	0.75	-0.05	-0.3	No trend	0.60	-0.03	-0.3
Pike	**Increase**	**0.97**	0.46	2.5	**Increase**	**0.97**	0.52	1.3	No trend	0.62	0.06	0.2
Poultney	No trend	0.50	0.00	-0.1	No trend	0.89	-0.06	-0.5	No trend	0.74	-0.05	-0.8
Putnam[a]	**Decrease**	**0.97**	-0.06	-1.6	**Decrease**	**0.99**	-0.09	-1.4	No trend	0.84	-0.03	-1.1
Salmon	**Decrease**	**0.95**	-0.05	-1.1	**Decrease**	**0.99**	-0.11	-1.0	**Decrease**	**0.96**	-0.05	-1.0
Saranac	**Decrease**	**0.97**	-0.08	-1.4	**Decrease**	**0.99**	-0.14	-1.2	**Decrease**	**0.99**	-0.07	-1.2
Winooski	**Increase**	**0.99**	0.19	2.3	No trend	0.67	0.04	0.2	**Decrease**	**0.99**	-0.15	-1.5


Total nitrogen load (10^3 kg N yr^-1)
Ausable
Boquet
Great Chazy
Lamoille
LaPlatte
Lewis
0
500
1000
1500
2000
1990
2000
2010


Total nitrogen load (10^3 kg N yr^{-1})
Little Ausable
Little Chazy
Little Otter
Mettawee
Missisquoi
Otter
0
500
1000
1500
2000
1990
2000
2010

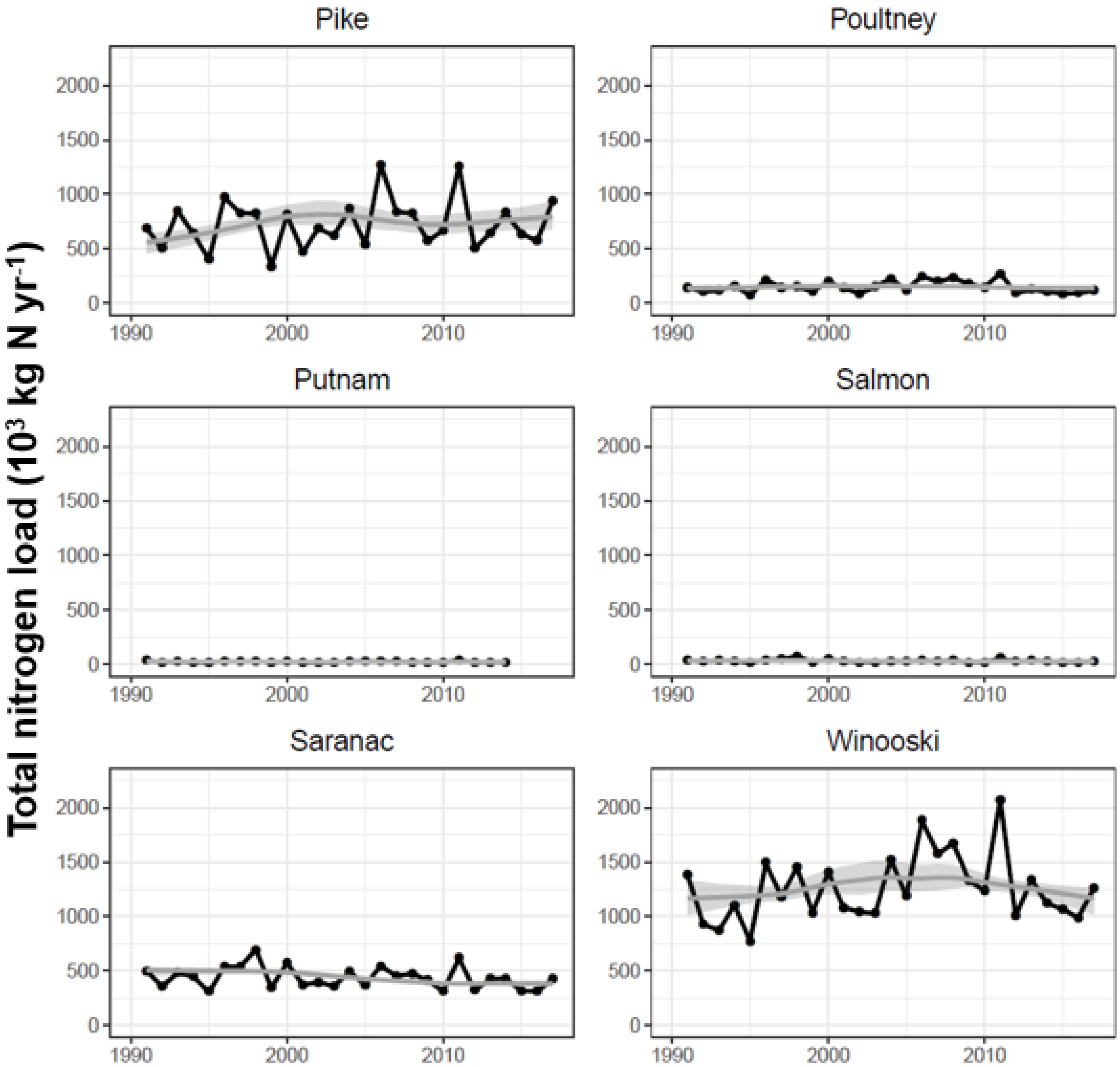


Figure 12. Estimated annual total nitrogen load (black dots and lines) and flow-normalized total nitrogen load (grey lines) with 95% confidence intervals (grey shaded areas) for eighteen Lake Champlain tributaries.

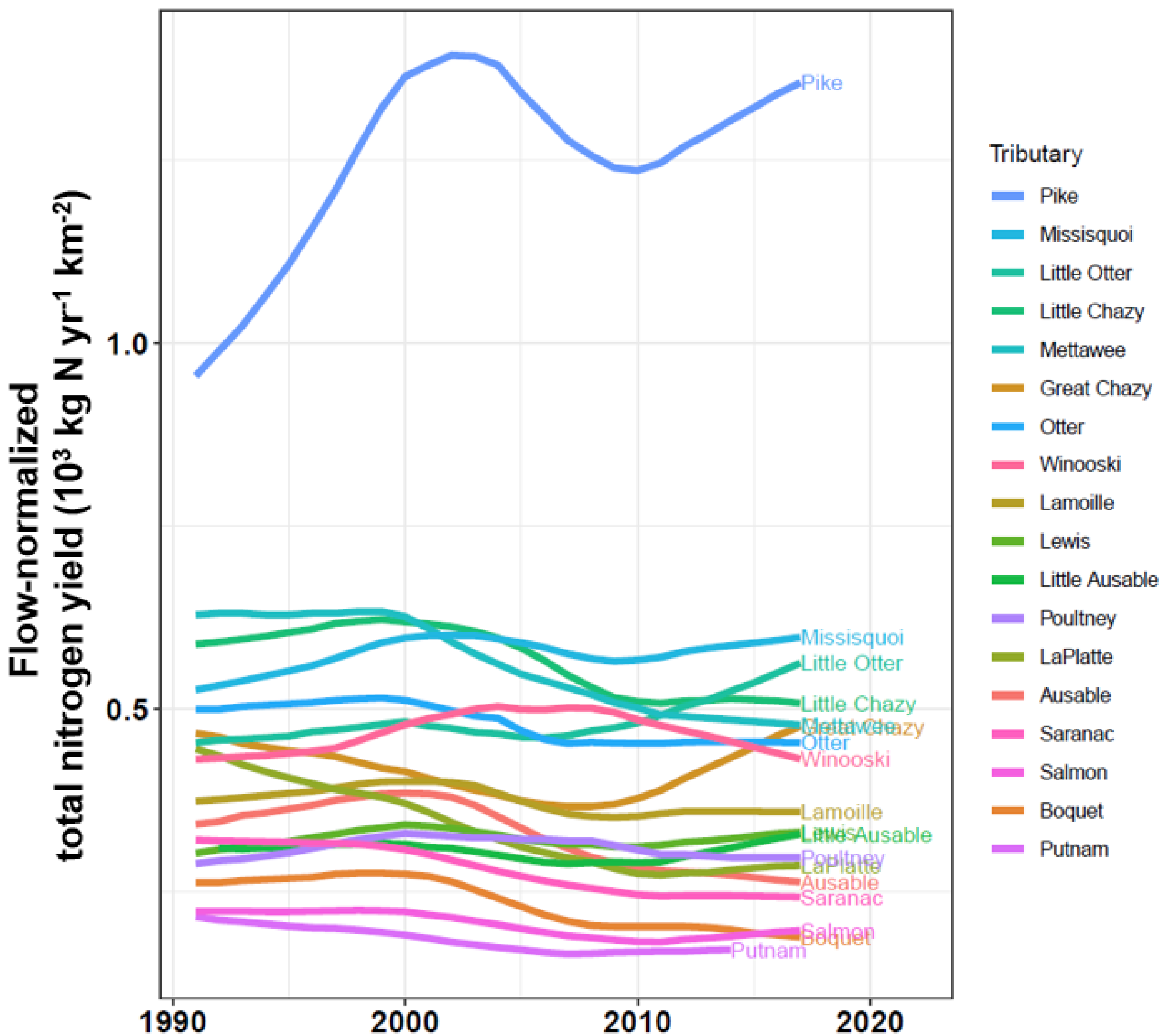


Figure 13. Plot of annual flow-normalized total nitrogen yield estimates for eighteen Lake Champlain tributaries. The flow-normalized yield is an estimate of load per watershed area, with the influence of annual water flux variability reduced. Note that the legend is in descending order by the latest value for each tributary.

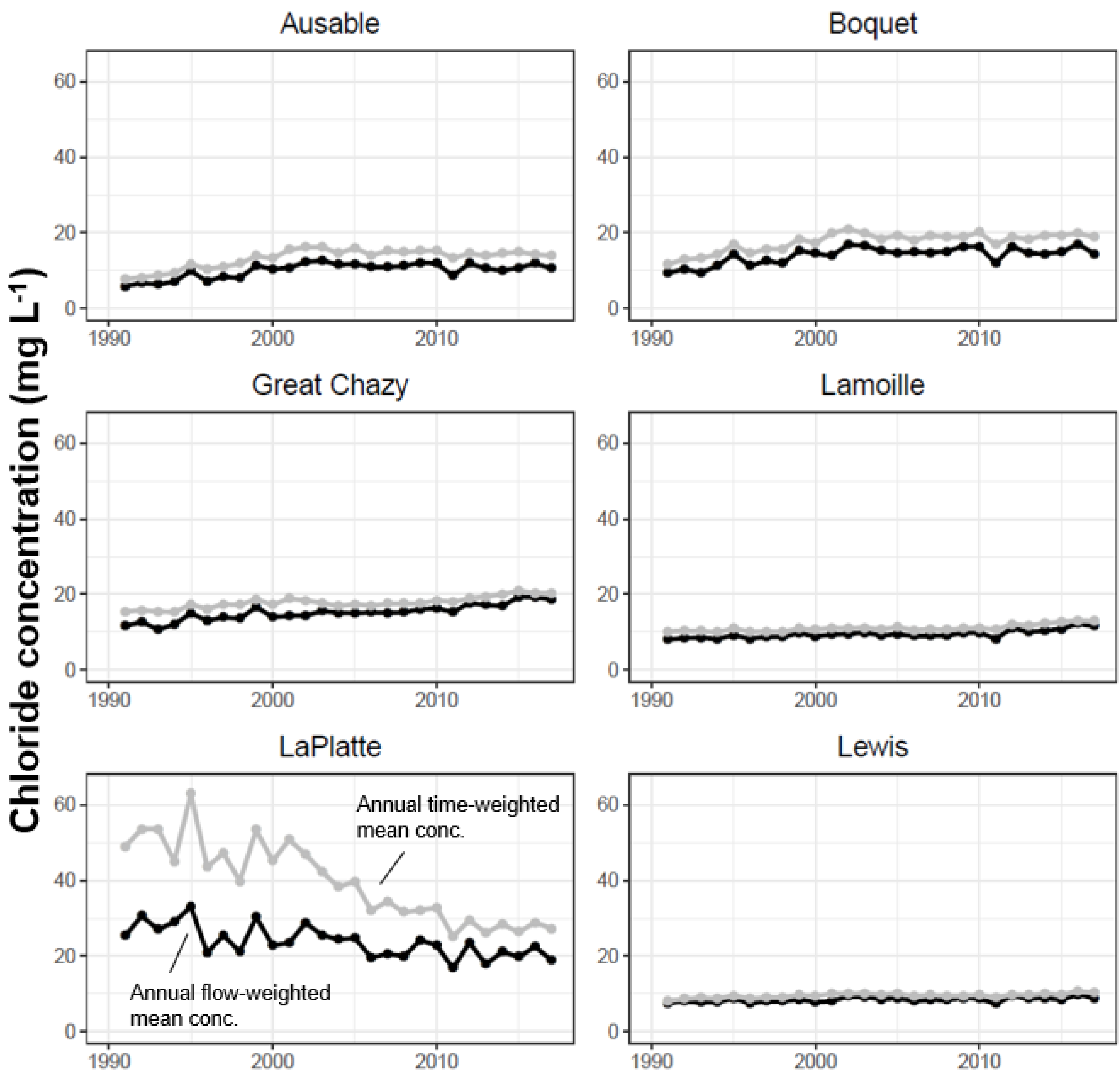
Table 8. Trend probabilities and magnitudes for **flow-normalized total nitrogen load** over three trend periods for eighteen Lake Champlain tributaries. Note that trend periods for ([a]) Putnam Creek end as late as 2013. Significant trends (probability ≥ 0.90) are outlined and shown in **bold**.

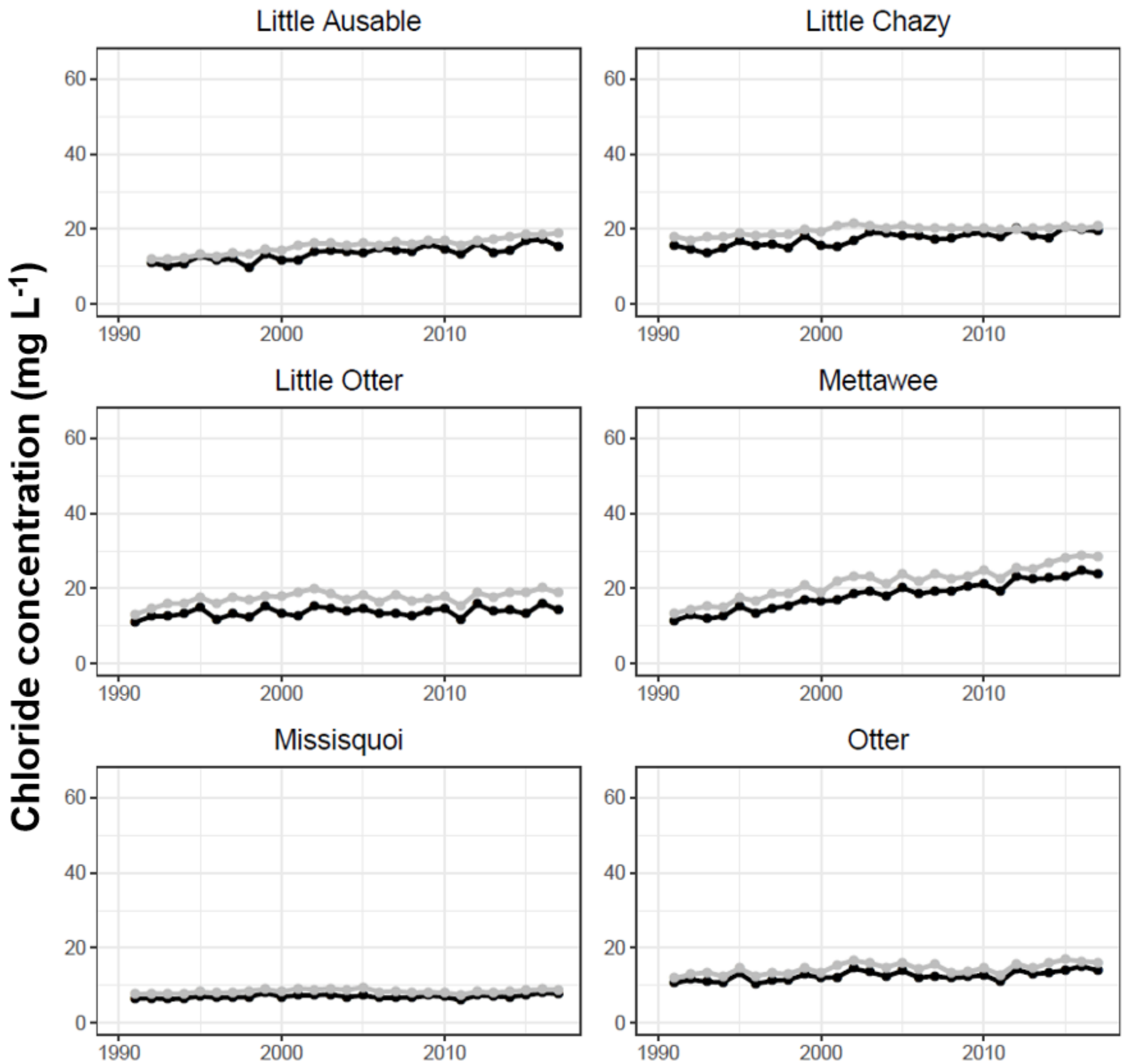
	First half (1993 to 2004)				Full record (1993 - 2017)				Second half (2004 to 2017)			
Tributary	Direction	Probability of trend	Change (10^3 kg yr^{-1})	Annualized percent change	Direction	Probability of trend	Change (10^3 kg yr^{-1})	Annualized percent change	Direction	Probability of trend	Change (10^3 kg yr^{-1})	Annualized percent change
Ausable	No trend	0.62	-1.7	0.0	No trend	0.90	-105.0	-1.2	**Decrease**	**0.99**	-103.0	-2.2
Boquet	No trend	0.82	-17.0	-0.9	No trend	0.84	-54.0	-1.4	**Decrease**	**0.99**	-37.0	-1.9
Great Chazy	**Decrease**	**0.97**	-44.0	-1.6	No trend	0.57	14.0	0.2	**Increase**	**0.94**	59.0	1.7
Lamoille	No trend	0.52	10.0	0.1	No trend	0.62	-35.0	-0.2	No trend	0.79	-46.0	-0.5
LaPlatte	No trend	0.90	-12.0	-2.5	**Decrease**	**0.98**	-16.0	-1.6	No trend	0.86	-4.1	-0.9
Lewis	No trend	0.62	3.4	0.5	No trend	0.65	4.2	0.3	No trend	0.55	0.8	0.1
Little Ausable	No trend	0.57	-1.4	-0.2	No trend	0.77	3.6	0.3	No trend	0.87	5.0	0.7
Little Chazy	No trend	0.67	0.2	0.0	No trend	0.85	-11.0	-0.7	**Decrease**	**0.91**	-12.0	-1.2
Little Otter	No trend	0.55	1.1	0.1	**Increase**	**0.99**	15.0	0.9	**Increase**	**0.97**	14.0	1.5
Mettawee	No trend	0.79	-30.0	-1.1	**Decrease**	**0.97**	-66.0	-1.1	**Decrease**	**0.97**	-36.0	-1.2
Missisquoi	**Increase**	**0.91**	126.0	1.0	No trend	0.89	130.0	0.4	No trend	0.67	4.6	0.0
Otter	No trend	0.74	-26.0	-0.3	**Decrease**	**0.92**	-80.0	-0.4	No trend	0.72	-55.0	-0.5
Pike	**Increase**	**0.99**	208.0	2.8	**Increase**	**0.99**	194.0	1.2	No trend	0.52	-14.0	-0.1
Poultney	No trend	0.89	14.0	0.9	No trend	0.55	0.6	0.0	No trend	0.79	-14.0	-0.7
Putnam[a]	**Decrease**	**0.96**	-4.6	-1.6	**Decrease**	**0.94**	-5.2	-1.0	No trend	0.62	-0.6	-0.3
Salmon	No trend	0.82	-3.0	-0.8	**Decrease**	**0.92**	-4.3	-0.5	No trend	0.76	-1.3	-0.3
Saranac	**Decrease**	**0.96**	-64.0	-1.3	**Decrease**	**0.99**	-120.0	-1.1	**Decrease**	**0.99**	-56.0	-1.1
Winooski	**Increase**	**0.97**	185.0	1.4	No trend	0.60	-9.6	0.0	**Decrease**	**0.99**	-195.0	-1.2

Chloride

In general, time-weighted mean chloride concentration values were higher than flow-weighted mean values, in contrast to these relationships for nutrients and total suspended solids (Figure 14). This is because baseflow chloride concentrations tended to be higher than chloride concentrations during storm events, when tributaries had more diluted concentrations. The LaPlatte River had relatively high chloride concentrations, and the largest difference between time- and flow-weighted annual mean concentrations. The LaPlatte River was the only tributary to demonstrate a significant decreasing trend in chloride concentration (Table 9). Nearly all (16) of the other tributaries showed significant increasing trends in flow-normalized chloride concentration for the full record trend period. Eight of these tributaries showed no trend in the second half of the record.

Annual chloride loads and yields in the Winooski River often exceeded those of all other tributaries, and the Mettawee River chloride yield was also relatively high (Figure 16 and Figure *17*). First-half and full-record significant increasing trends in flow-normalized chloride load were observed in all but two tributaries, where full record decreasing trends were found (Pike and LaPlatte Rivers; Table 10). Seven of these sixteen tributaries showed no trend in flow-normalized load in the second half of the record: the Ausable, Boquet, Mettawee, Missisquoi, and Winooski Rivers, and Lewis and Otter Creeks. Although the Putnam Creek increased in flow-normalized load for the full and first half of record, it showed a decrease for the second half of the record.


Ausable
Boquet
Great Chazy
Lamoille
LaPlatte
Lewis
Chloride concentration (mg L-1)
Annual time-weighted mean conc.
Annual flow-weighted mean conc.
0
20
40
60
1990
2000
2010


Chloride concentration (mg L-1)
Little Ausable
Little Chazy
Little Otter
Mettawee
Missisquoi
Otter
0
20
40
60
1990
2000
2010

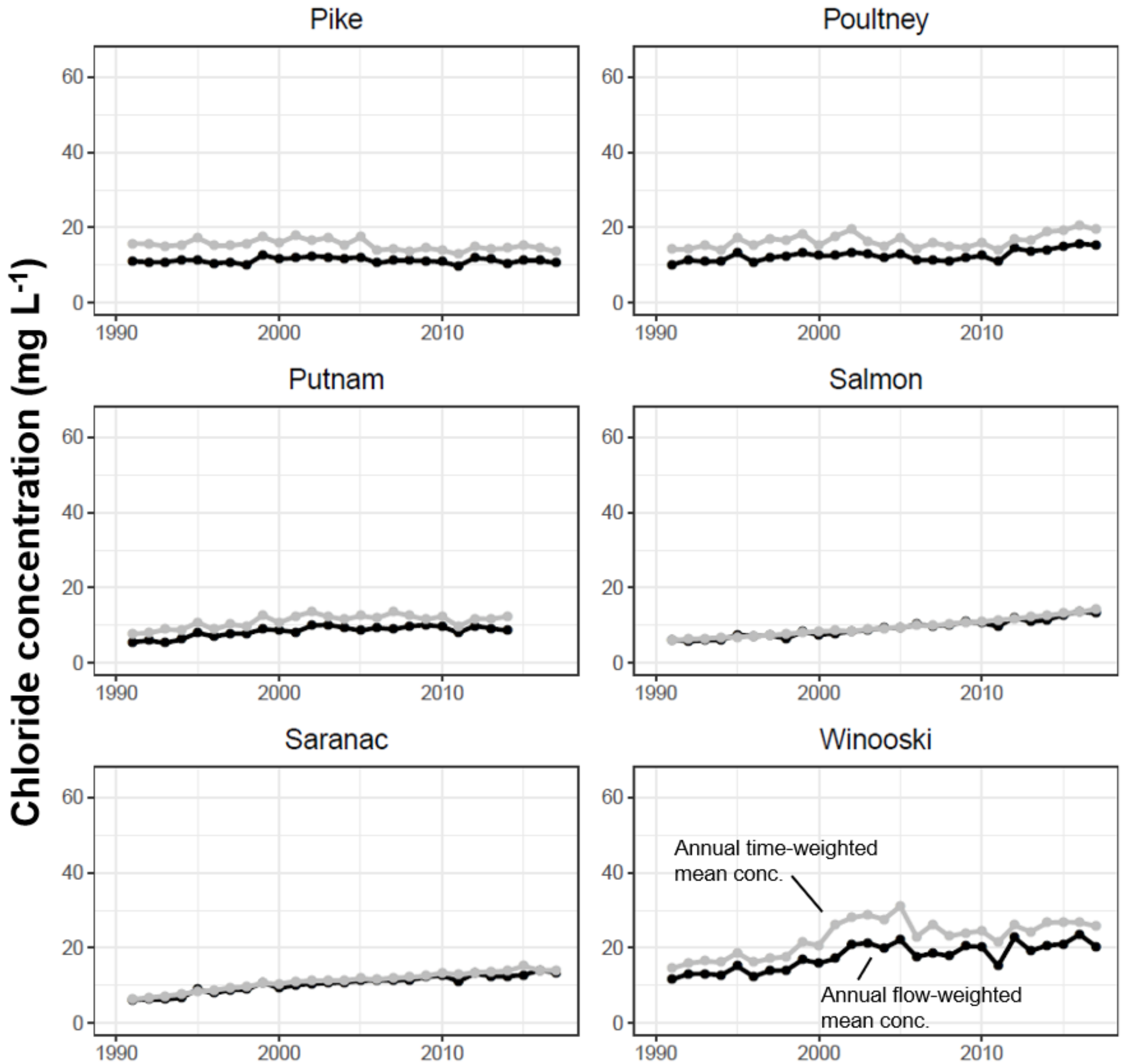


Figure 14. Estimated annual flow-weighted mean (black dots and lines) and time-weighted mean (grey dots and lines) chloride concentrations for eighteen Lake Champlain tributaries.

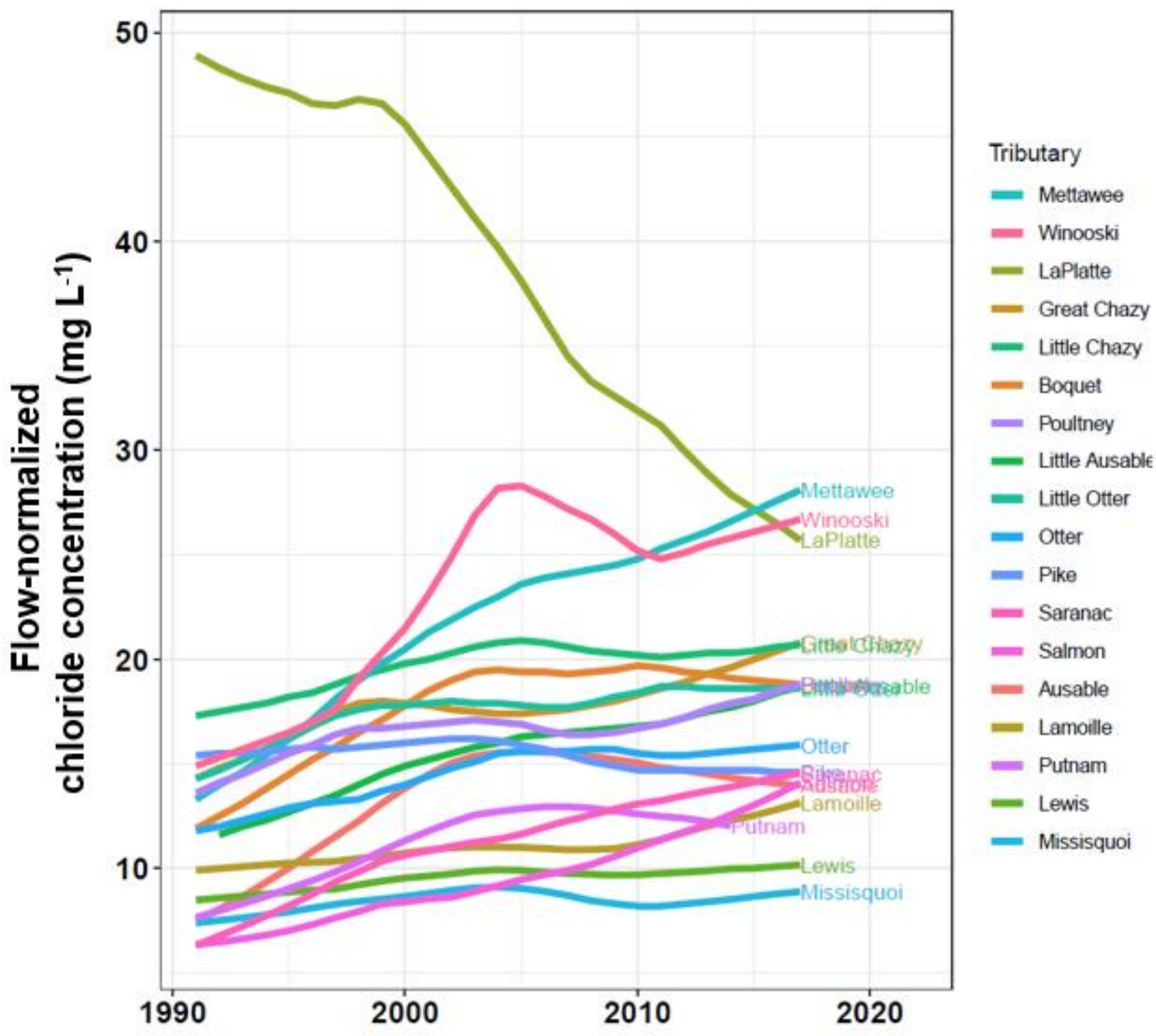
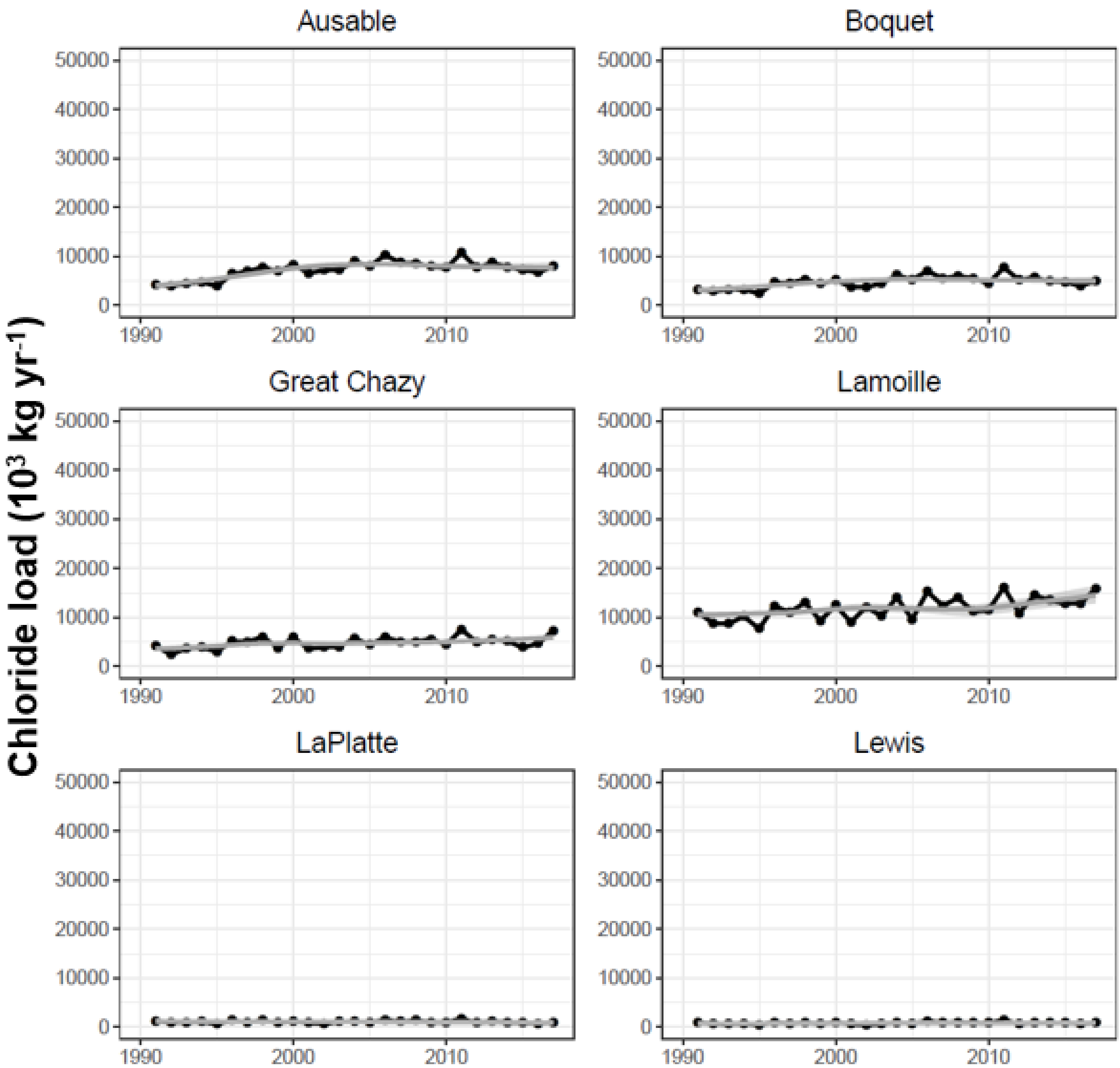
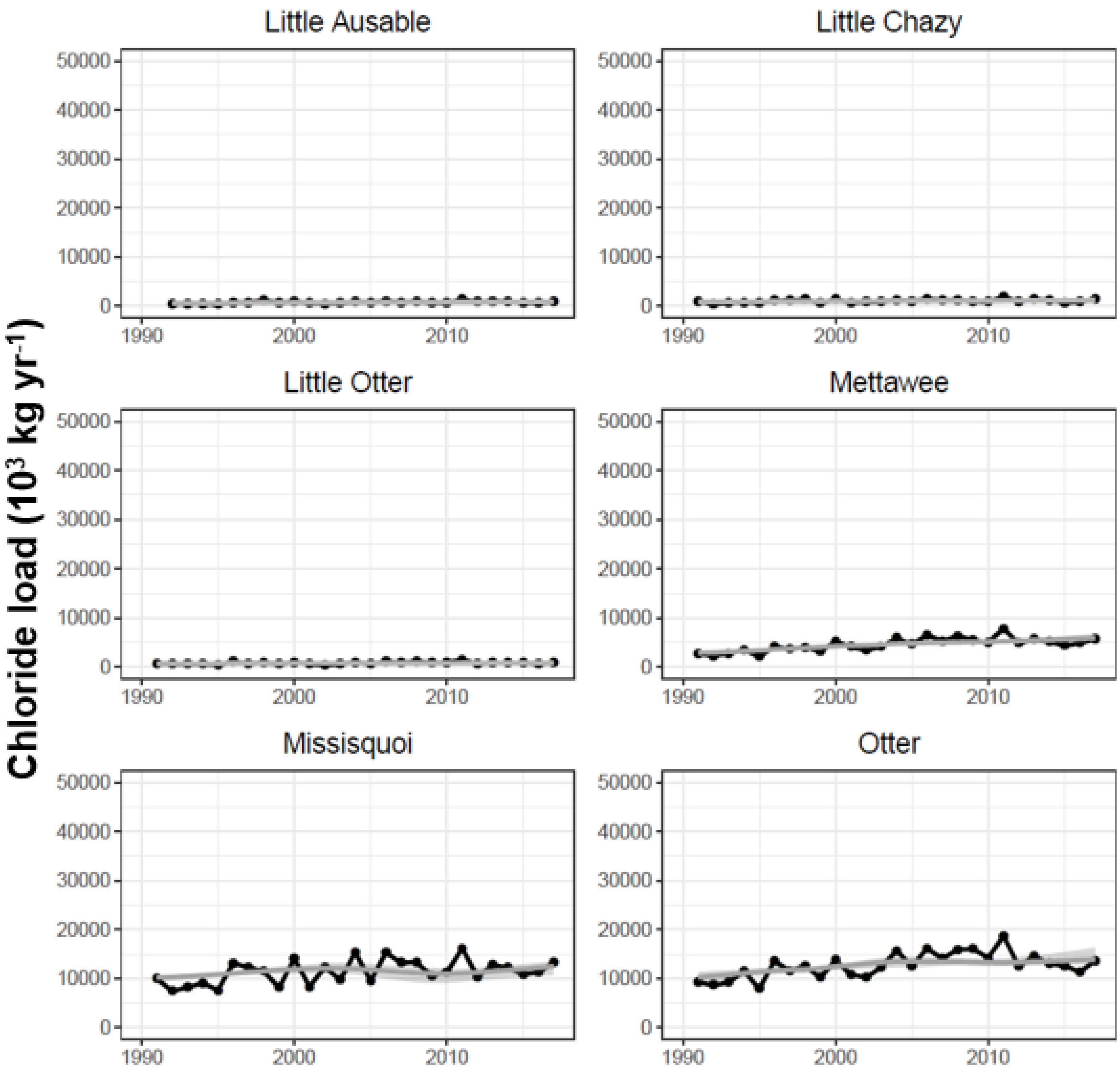


Figure 15. Plot of annual flow-normalized chloride concentration estimates for eighteen Lake Champlain tributaries. The annual flow-normalized concentration is an estimate of the annual mean concentration with the influence of annual water flux variability reduced. Note that the legend is in descending order by the latest value for each tributary.

Table 9. Trend probabilities and magnitudes for **flow-normalized chloride concentration** over three trend periods for eighteen Lake Champlain tributaries. Note that trend periods for (*) Little Ausable River begin as early as 1993, and trend periods for ([a]) Putnam Creek end as late as 2013. Significant trends (probability ≥ 0.90) are outlined and shown in **bold**.

	First half (1991 to 2004)				Full record (1991 - 2017)				Second half (2004 to 2017)			
Tributary	Direction	Probability of trend	Change (mg L^{-1})	Annualized percent change	Direction	Probability of trend	Change (mg L^{-1})	Annualized percent change	Direction	Probability of trend	Change (mg L^{-1})	Annualized percent change
Ausable	**Increase**	**0.99**	8.1	5.8	**Increase**	**0.99**	6.5	2.4	No trend	0.90	-1.6	-0.8
Boquet	**Increase**	**0.99**	7.6	3.8	**Increase**	**0.99**	6.8	1.8	No trend	0.67	-0.7	-0.3
Great Chazy	**Increase**	**0.99**	3.1	1.5	**Increase**	**0.99**	6.5	1.5	**Increase**	**0.99**	3.5	1.4
Lamoille	No trend	0.88	1.1	0.8	**Increase**	**0.97**	3.2	1.1	**Increase**	**0.93**	2.1	1.3
LaPlatte	**Decrease**	**0.98**	-9.2	-1.6	**Decrease**	**0.99**	-23.0	-2.4	**Decrease**	**1.00**	-14.0	-3.3
Lewis	**Increase**	**0.99**	1.4	1.2	**Increase**	**0.97**	1.7	0.7	No trend	0.67	0.2	0.2
Little Ausable*	**Increase**	**0.99**	4.4	2.7	**Increase**	**0.99**	7.1	1.9	**Increase**	**0.99**	2.7	1.2
Little Chazy	**Increase**	**0.99**	3.6	1.5	**Increase**	**0.99**	3.4	0.7	No trend	0.52	-0.1	0.0
Little Otter	**Increase**	**0.99**	3.6	1.7	**Increase**	**0.99**	4.4	1.0	**Increase**	**0.96**	0.8	0.3
Mettawee	**Increase**	**0.99**	9.7	4.3	**Increase**	**0.99**	15.0	2.9	**Increase**	**0.99**	5.1	1.5
Missisquoi	**Increase**	**0.99**	1.7	1.6	**Increase**	**0.92**	1.5	0.7	No trend	0.70	-0.2	-0.2
Otter	**Increase**	**0.99**	3.8	2.2	**Increase**	**0.99**	4.2	1.2	No trend	0.74	0.4	0.2
Pike	No trend	0.70	0.7	0.3	No trend	0.80	-0.9	-0.2	No trend	0.90	-1.5	-0.8
Poultney	**Increase**	**0.99**	3.4	1.7	**Increase**	**0.99**	5.2	1.2	**Increase**	**0.97**	1.8	0.7
Putnam[a]	**Increase**	**0.99**	5.1	4.0	**Increase**	**0.99**	4.6	2.2	No trend	0.72	-0.5	-0.4
Salmon	**Increase**	**0.99**	2.8	2.9	**Increase**	**0.99**	7.7	3.1	**Increase**	**0.99**	4.9	3.4
Saranac	**Increase**	**0.99**	5.1	4.7	**Increase**	**0.99**	8.2	3.3	**Increase**	**0.99**	3.2	1.9
Winooski	**Increase**	**0.99**	13.0	5.0	**Increase**	**0.99**	12.0	2.3	No trend	0.74	-1.5	-0.4


Ausable
Boquet
Great Chazy
Lamoille
LaPlatte
Lewis
Chloride load (10^3 kg yr^{-1})
50000
40000
30000
20000
10000
0
1990
2000
2010


Little Ausable
Little Chazy
Little Otter
Mettawee
Missisquoi
Otter
Chloride load (10³ kg yr⁻¹)
50000
40000
30000
20000
10000
0
1990
2000
2010

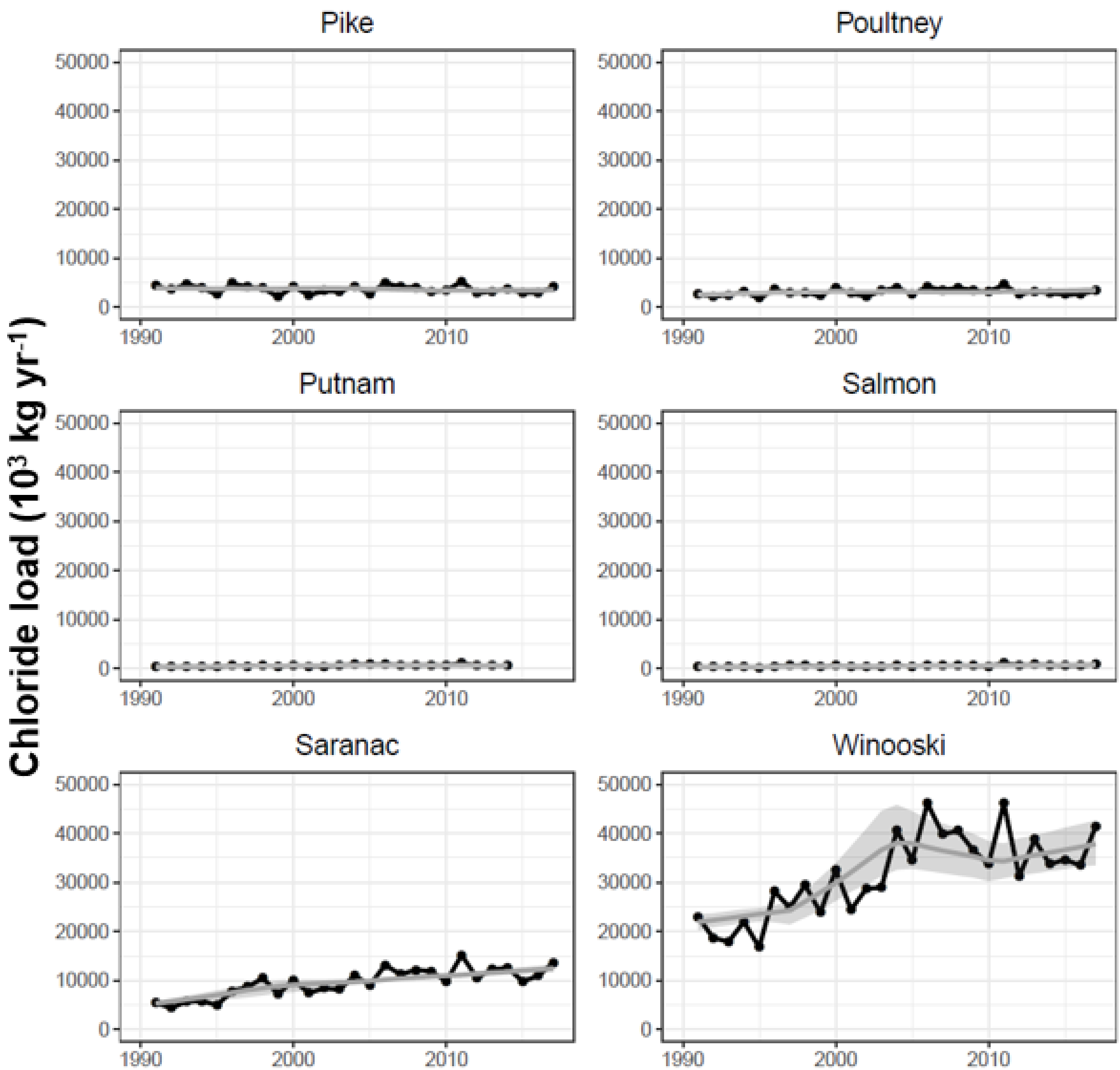


Figure 16. Estimated annual chloride load (black dots and lines) and flow-normalized chloride load (grey lines) with 95% confidence intervals (grey shaded areas) for eighteen Lake Champlain tributaries.

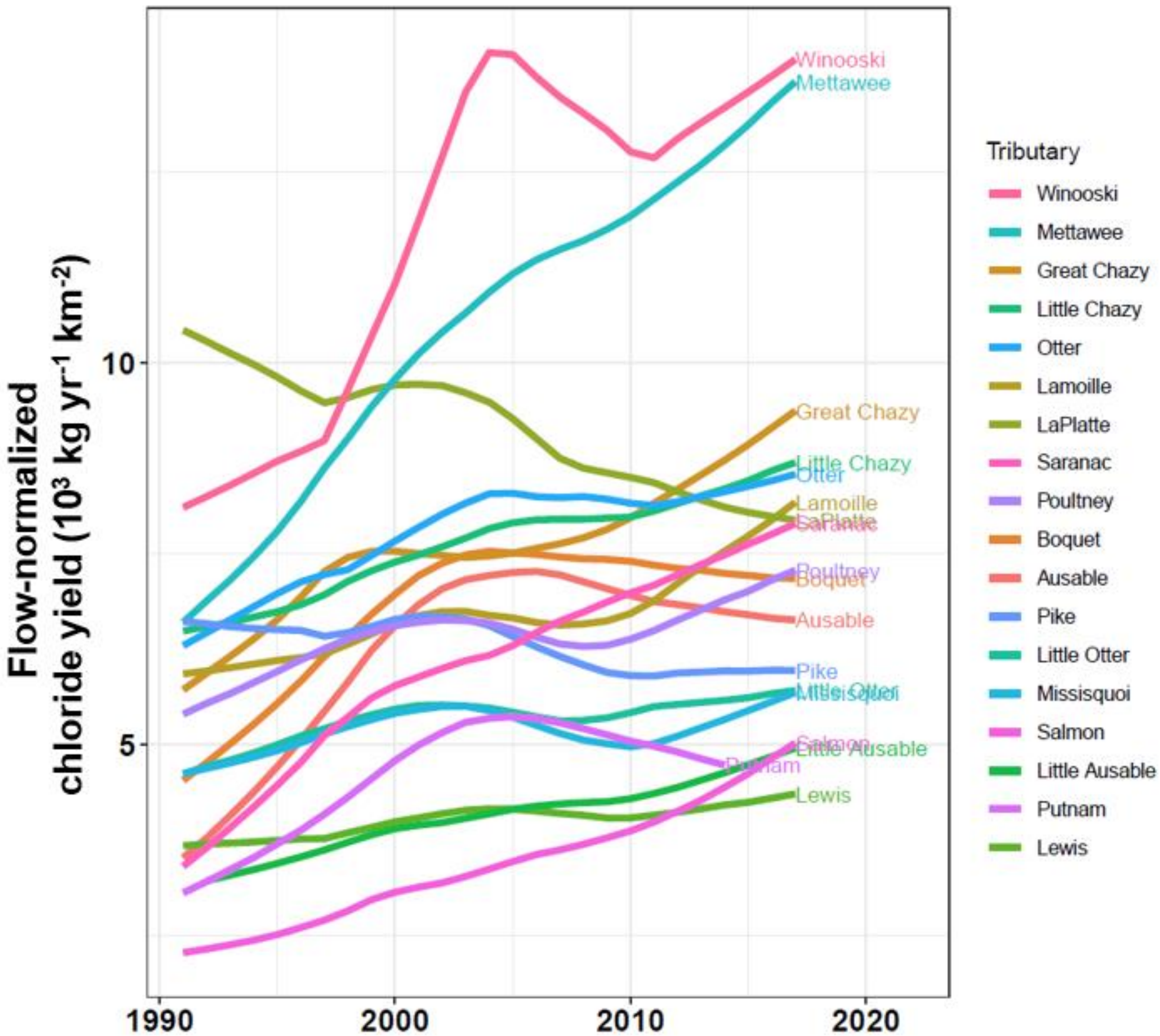


Figure 17. Plot of annual flow-normalized chloride yield estimates for eighteen Lake Champlain tributaries. The flow-normalized yield is an estimate of load per watershed area, with the influence of annual water flux variability reduced. Note that the legend is in descending order by the latest value for each tributary.

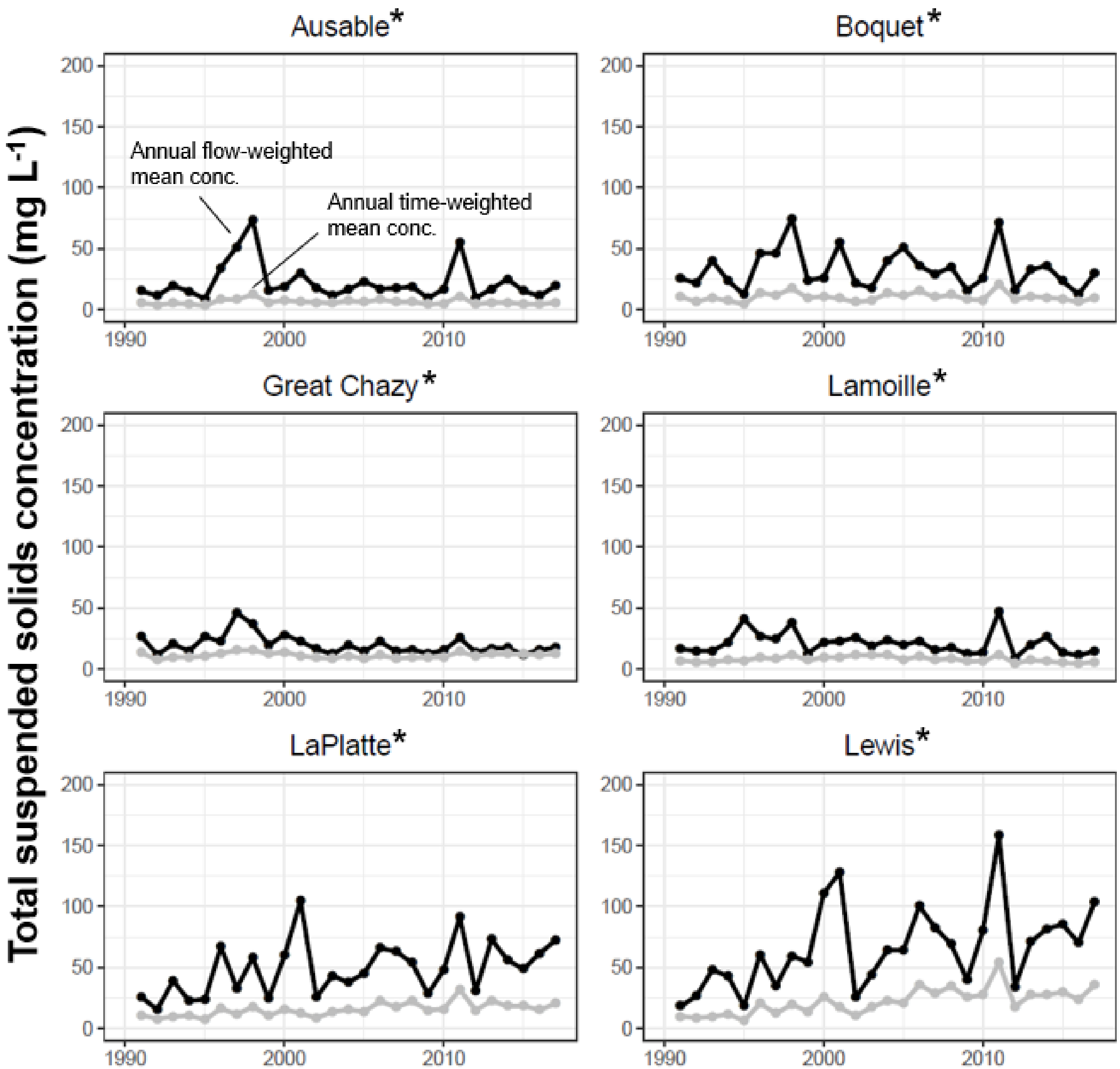
Table 10. Trend probabilities and magnitudes for **flow-normalized chloride load** over three trend periods for eighteen Lake Champlain tributaries. Note that trend periods for (*) Little Ausable River begin as early as 1993, and trend periods for ([a]) Putnam Creek end as late as 2013. Significant trends (probability ≥ 0.90) are outlined and shown in **bold**.

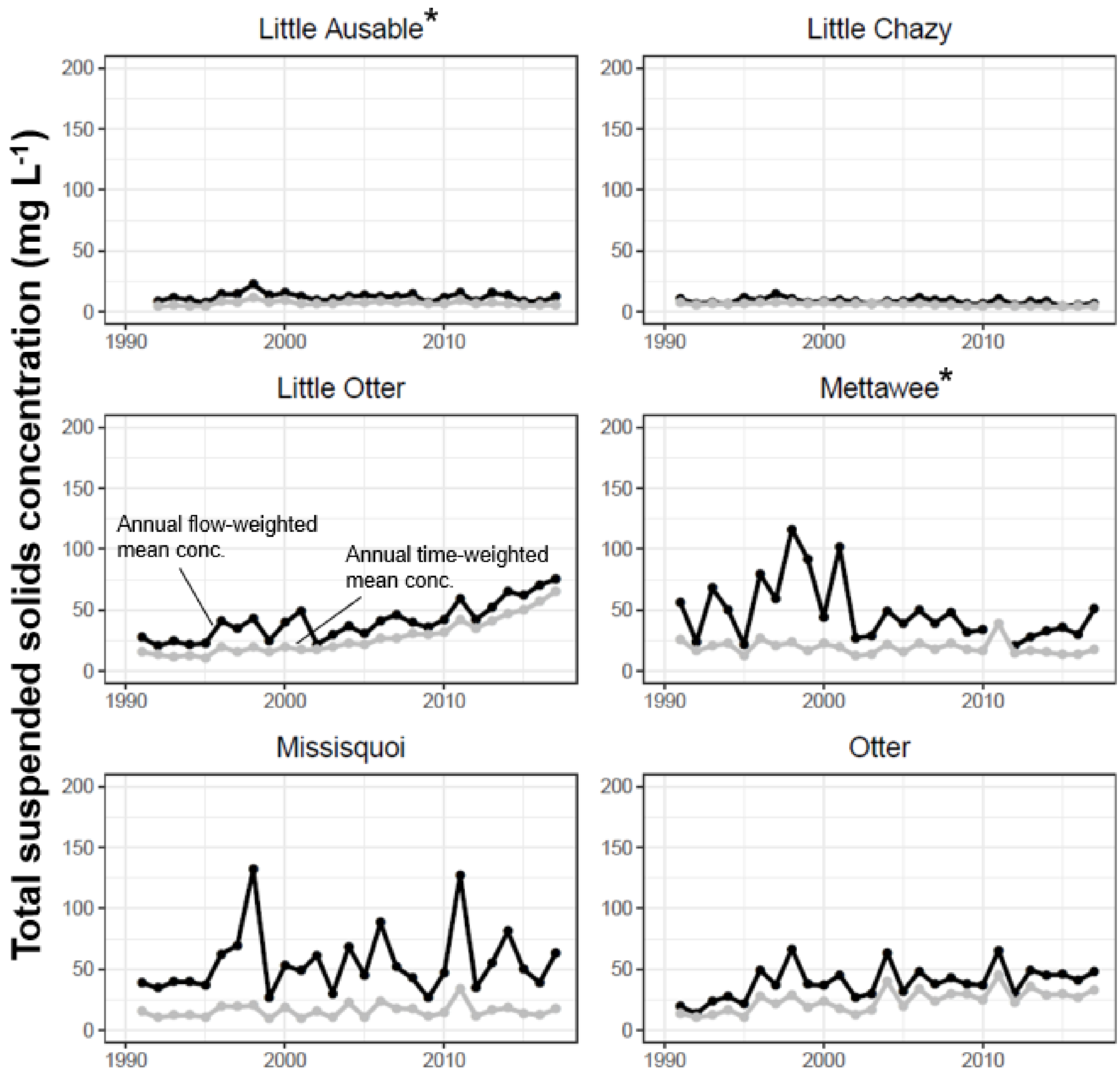
	First half (1991 to 2004)				Full record (1991 - 2017)				Second half (2004 to 2017)			
Tributary	Direction	Probability of trend	Change (10^3 kg yr^{-1})	Annualized percent change	Direction	Probability of trend	Change (10^3 kg yr^{-1})	Annualized percent change	Direction	Probability of trend	Change (10^3 kg yr^{-1})	Annualized percent change
Ausable	**Increase**	**0.99**	4276	5.7	**Increase**	**0.99**	3601	2.5	No trend	0.85	-675	-0.6
Boquet	**Increase**	**0.99**	2099	4.0	**Increase**	**0.99**	1849	1.8	No trend	0.70	-250	-0.4
Great Chazy	**Increase**	**0.99**	1105	2.1	**Increase**	**0.99**	2302	1.9	**Increase**	**0.99**	1197	1.7
Lamoille	**Increase**	**0.97**	1365	0.9	**Increase**	**0.99**	3999	1.2	**Increase**	**0.97**	2634	1.5
LaPlatte	**Decrease**	**0.95**	-109	-0.7	**Decrease**	**0.99**	-288	-1.0	**Decrease**	**0.97**	-180	-1.3
Lewis	**Increase**	**0.99**	97	0.9	**Increase**	**0.97**	135	0.6	No trend	0.79	38	0.3
Little Ausable*	**Increase**	**0.99**	154	2.0	**Increase**	**0.99**	306	1.7	**Increase**	**0.99**	152	1.5
Little Chazy	**Increase**	**0.99**	175	1.5	**Increase**	**0.99**	289	1.1	**Increase**	**0.99**	114	0.8
Little Otter	**Increase**	**0.99**	129	1.3	**Increase**	**0.99**	162	0.8	**Increase**	**0.92**	34	0.3
Mettawee	**Increase**	**0.99**	1873	4.0	**Increase**	**0.99**	3066	2.8	**Increase**	**0.99**	1193	1.7
Missisquoi	**Increase**	**0.99**	1817	1.3	**Increase**	**0.98**	2336	0.8	No trend	0.82	519	0.3
Otter	**Increase**	**0.99**	3236	2.2	**Increase**	**0.99**	3654	1.2	No trend	0.74	417	0.2
Pike	No trend	0.57	-32	-0.1	**Decrease**	**0.91**	-375	-0.4	No trend	0.85	-343	-0.7
Poultney	**Increase**	**0.99**	578	1.5	**Increase**	**0.99**	914	1.2	**Increase**	**1.00**	337	0.8
Putnam[a]	**Increase**	**0.99**	305	4.4	**Increase**	**0.99**	234	2.1	**Decrease**	**0.91**	-71	-1.2
Salmon	**Increase**	**0.99**	180	3.1	**Increase**	**0.99**	451	3.1	**Increase**	**0.99**	271	3.1
Saranac	**Increase**	**0.99**	4356	4.7	**Increase**	**0.99**	7077	3.3	**Increase**	**0.99**	2721	1.9
Winooski	**Increase**	**0.99**	16126	4.4	**Increase**	**0.99**	15887	2.1	No trend	0.65	-239	0.0

Total suspended solids

Because validations showed that many of the models to predict total suspended solids concentration and load were biased (Table 2), results below should be interpreted with care and with the caveat that they have notable uncertainty. Annual flow-weighted mean total suspended solids concentrations were heavily influenced by annual discharge variability and were consistently higher than annual time-weighted mean values (Figure 18). For 8 out of 18 tributaries, no trends in flow-normalized total suspended solids concentration were found for any trend period (Table 11). Full record significant increases in flow-normalized concentration were found in the LaPlatte and Poultney Rivers and Lewis, Little Otter, and Otter Creeks. However, Lewis and Otter Creeks had no significant trends in the second half of record. In contrast, the Winooski River had no trend in flow-normalized concentration in the first half of record, but significantly increased in the second half of record.

Winooski and Missisquoi Rivers had the highest annual total suspended solids loads, at times exceeding an estimated 300,000 metric tons per year (Figure 20). In addition to these two tributaries, the Poultney River had relatively high annual flow-normalized total suspended solids yields (Figure 21). Although five tributaries had significantly increasing trends in flow-normalized load for the full record trend period (LaPlatte, Missisquoi, and Pike Rivers, and Lewis and Little Otter Creeks), only two had significantly increasing trends in the second half of record (Little Otter Creek and Winooski River) (Table 12). Three tributaries showed significant decreases in flow-normalized load: Lamoille River for the full record trend period, and Little Ausable and Little Chazy Rivers for the second half of record.


Ausable*
Boquet*
Great Chazy*
Lamoille*
LaPlatte*
Lewis*
Total suspended solids concentration (mg L-1)
Annual flow-weighted mean conc.
Annual time-weighted mean conc.
0
50
100
150
200
1990
2000
2010


Total suspended solids concentration (mg L-1)
Little Ausable*
Little Chazy
Little Otter
Mettawee*
Missisquoi
Otter
Annual flow-weighted mean conc.
Annual time-weighted mean conc.
0
50
100
150
200
1990
2000
2010

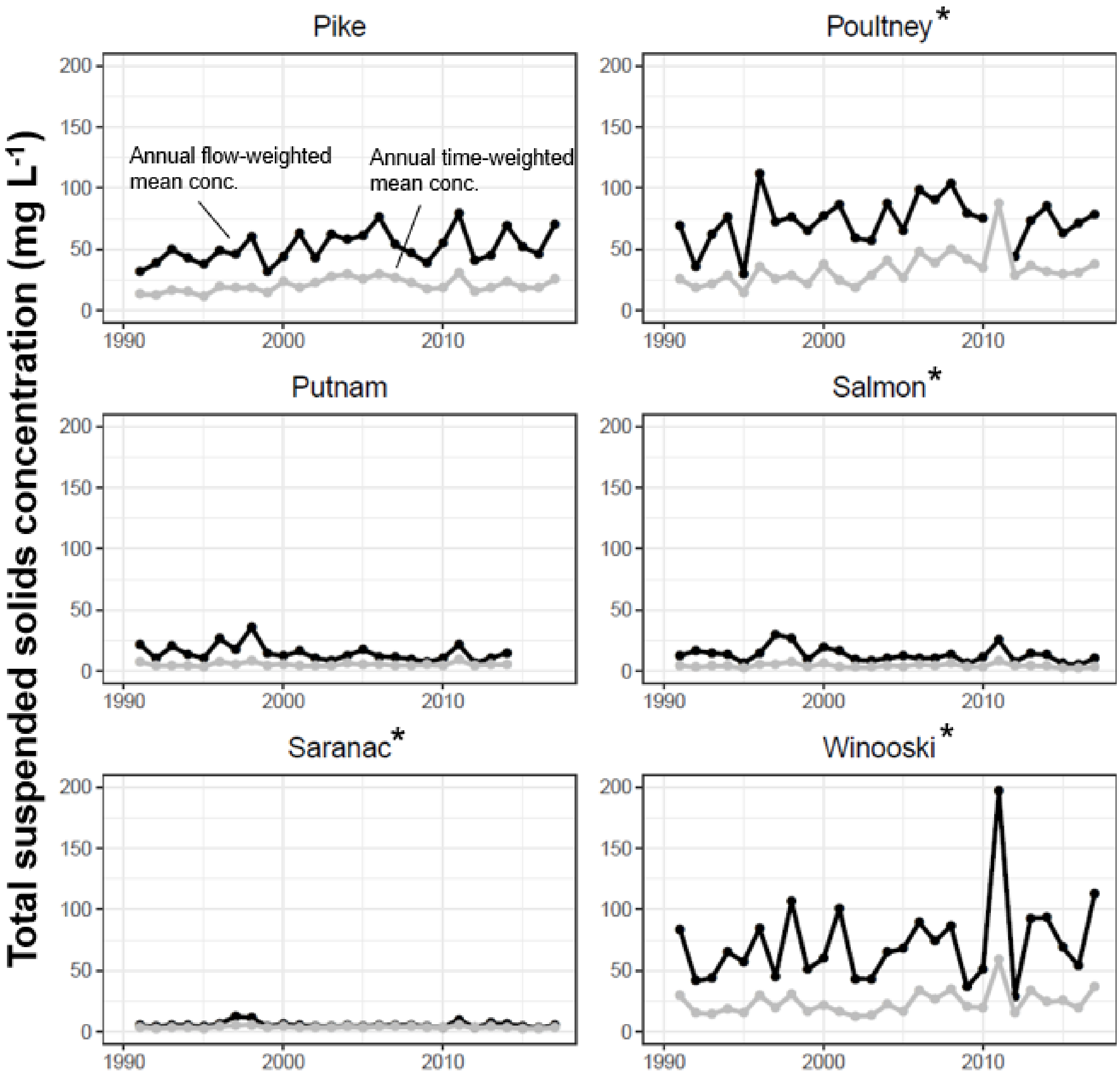


Figure 18. Estimated annual flow-weighted mean (black dots and lines) and time-weighted mean (grey dots and lines) total suspended solids concentrations for eighteen Lake Champlain tributaries. An asterisk (*) indicates that the flux bias statistic was outside of the acceptable range and that the results should be interpreted with care.

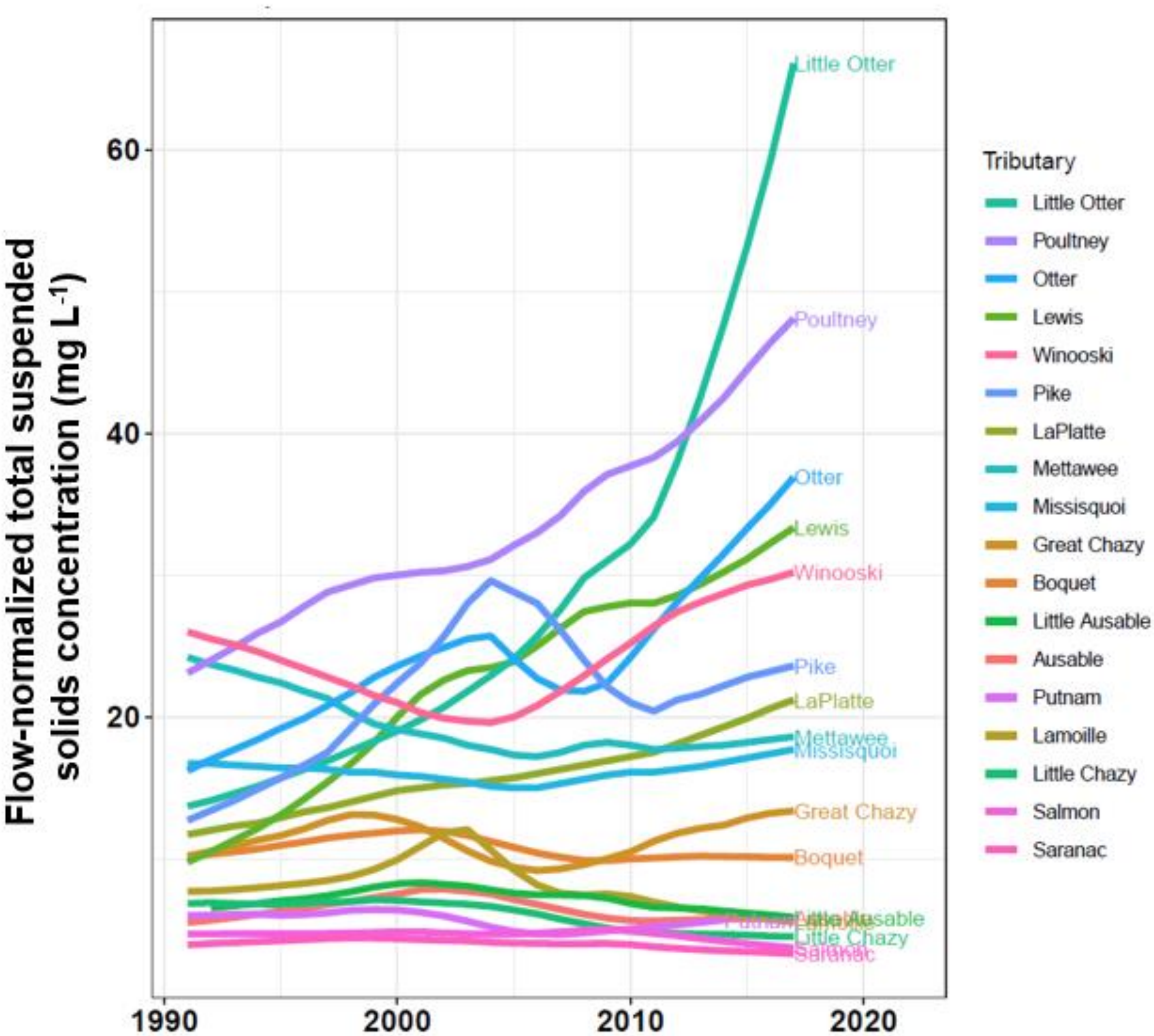
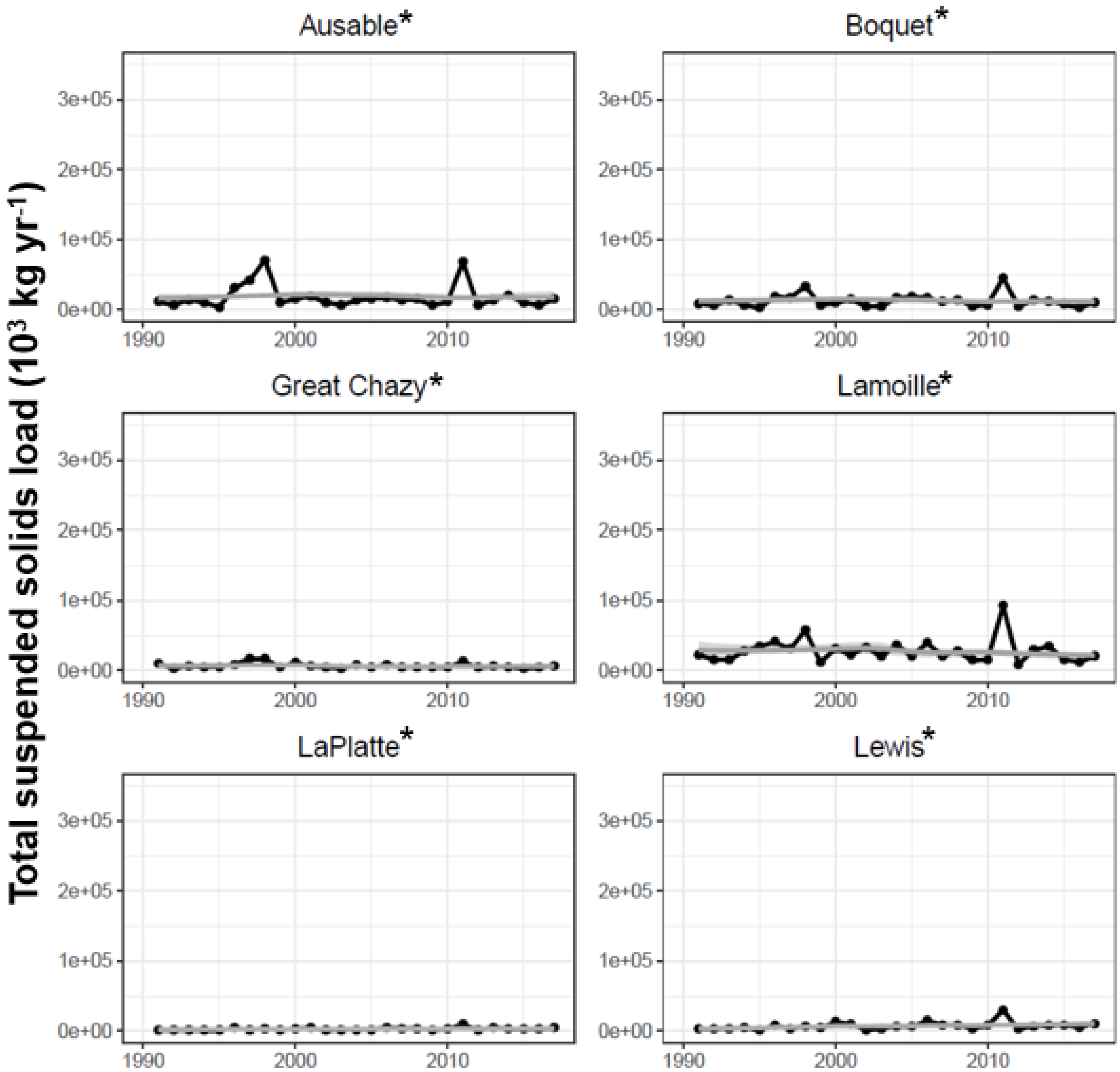
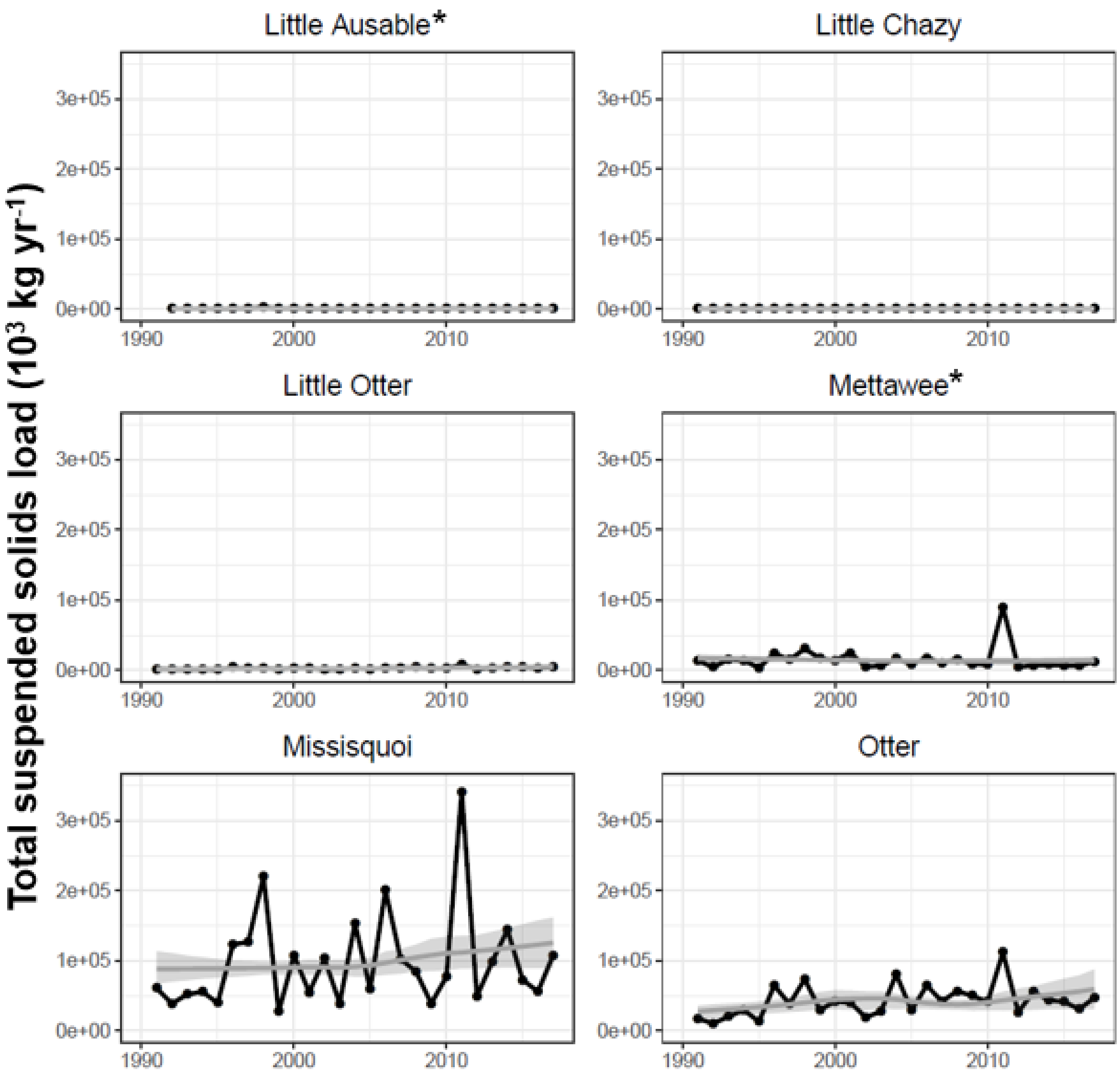


Figure 19. Plot of annual flow-normalized total suspended solids concentration estimates for eighteen Lake Champlain tributaries. The annual flow-normalized concentration is an estimate of the annual mean concentration with the influence of annual water flux variability reduced. Note that the legend is in descending order by the latest value for each tributary.

Table 11. Trend probabilities and magnitudes for **flow-normalized total suspended solids concentration** over three trend periods for eighteen Lake Champlain tributaries. Note that trend periods for ([a]) Putnam Creek end as late as 2013. Significant trends (probability ≥ 0.90) are outlined and shown in **bold**.

	First half (1993 to 2004)				Full record (1993 - 2017)				Second half (2004 to 2017)			
Tributary	Direction	Probability of trend	Change (mg L^{-1})	Annualized percent change	Direction	Probability of trend	Change (mg L^{-1})	Annualized percent change	Direction	Probability of trend	Change (mg L^{-1})	Annualized percent change
Ausable	**Increase**	**0.90**	1.7	2.3	No trend	0.65	0.0	0.0	No trend	0.89	-1.7	-2.0
Boquet	No trend	0.67	0.7	0.6	No trend	0.65	-0.4	-0.2	No trend	0.62	-1.1	-0.8
Great Chazy	No trend	0.55	-1.1	-0.9	No trend	0.70	2.5	0.9	No trend	0.60	3.5	2.4
Lamoille	No trend	0.65	2.8	2.8	No trend	0.89	-2.3	-1.4	No trend	0.74	-5.1	-4.9
LaPlatte	No trend	0.79	3.2	2.1	**Increase**	**0.97**	8.9	2.3	**Increase**	**0.99**	5.7	2.4
Lewis	**Increase**	**0.99**	12.0	6.9	**Increase**	**0.97**	22.0	4.6	No trend	0.87	9.9	2.7
Little Ausable	**Increase**	**0.92**	1.1	1.4	No trend	0.57	-0.8	-0.5	**Decrease**	**0.98**	-1.9	-2.2
Little Chazy	No trend	0.55	-0.2	-0.3	No trend	0.89	-2.3	-1.7	**Decrease**	**0.97**	-2.1	-2.9
Little Otter	No trend	0.84	8.3	4.1	**Increase**	**0.99**	51.0	6.5	**Increase**	**0.99**	43.0	8.5
Mettawee	No trend	0.74	-5.6	-2.5	No trend	0.84	-4.7	-0.9	No trend	0.62	0.9	0.4
Missisquoi	No trend	0.79	-1.4	-0.8	No trend	0.65	1.1	0.3	No trend	0.89	2.6	1.2
Otter	No trend	0.85	8.0	3.4	**Increase**	**0.91**	19.0	3.1	No trend	0.74	11.0	2.8
Pike	**Increase**	**0.96**	16.0	7.0	No trend	0.88	9.5	2.2	No trend	0.79	-6.0	-1.7
Poultney	**Increase**	**0.91**	6.2	2.0	**Increase**	**0.97**	23.0	2.8	**Increase**	**0.95**	17.0	3.4
Putnam[a]	No trend	0.50	-0.9	-1.5	No trend	0.50	-0.6	-0.5	No trend	0.74	0.3	0.7
Salmon	No trend	0.52	0.0	-0.1	No trend	0.72	-1.0	-1.0	No trend	0.84	-1.0	-1.8
Saranac	No trend	0.55	0.0	0.0	No trend	0.74	-0.8	-0.9	No trend	0.87	-0.8	-1.7
Winooski	No trend	0.82	-5.4	-2.2	No trend	0.90	5.1	0.8	**Increase**	**0.96**	11.0	3.4


Total suspended solids load (10³ kg yr⁻¹)
Ausable*
Boquet*
Great Chazy*
Lamoille*
LaPlatte*
Lewis*
3e+05
2e+05
1e+05
0e+00
1990
2000
2010


Little Ausable*
Little Chazy
Little Otter
Mettawee*
Missisquoi
Otter
Total suspended solids load (10^3 kg yr^{-1})
3e+05
2e+05
1e+05
0e+00
1990
2000
2010

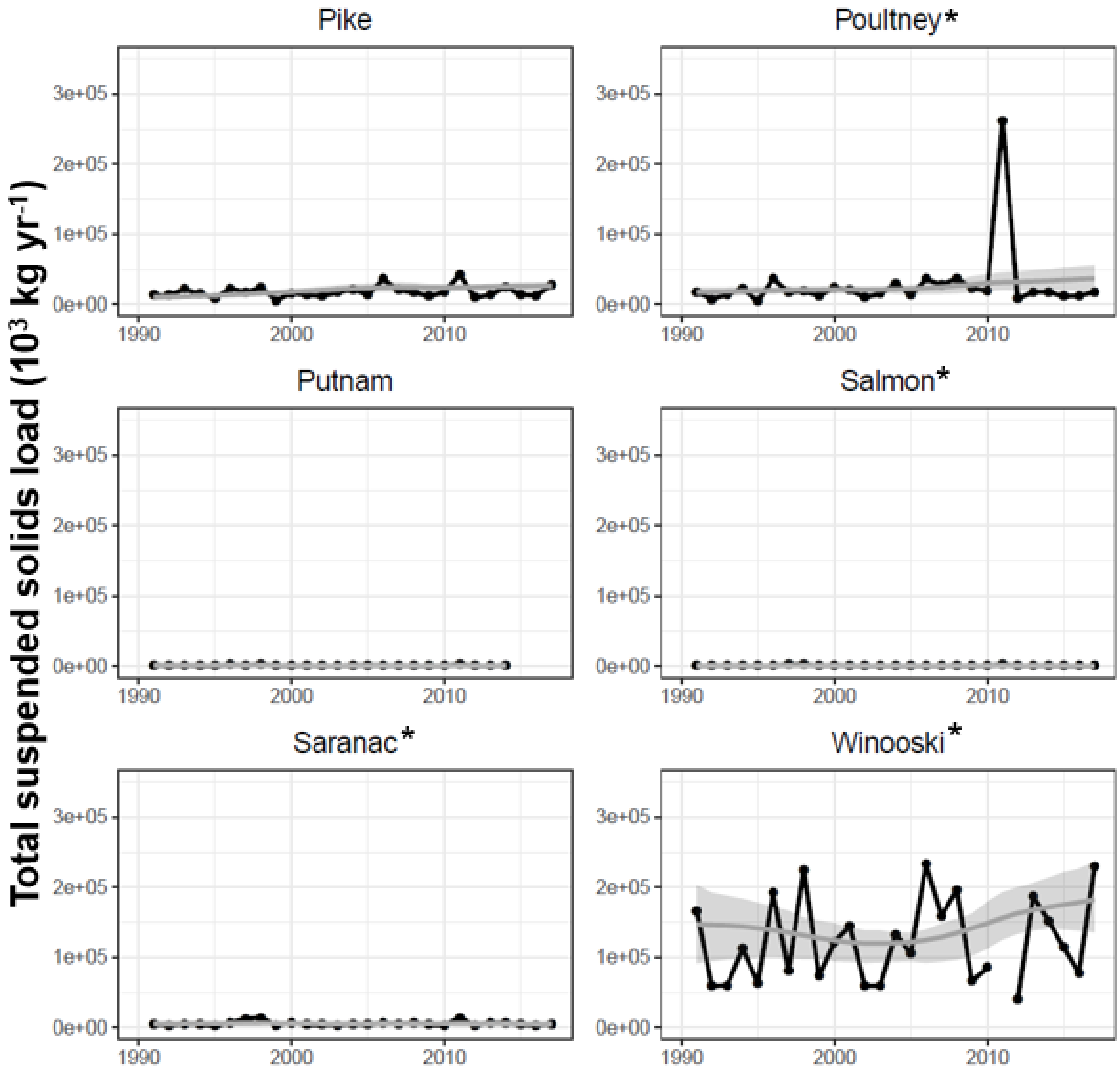


Figure 20. Estimated annual total suspended solids load (black dots and lines) and flow-normalized total suspended solids load (grey lines) with 95% confidence intervals (grey shaded areas) for eighteen Lake Champlain tributaries. An asterisk (*) indicates that the flux bias statistic was outside of the acceptable range and that the results should be interpreted with care.

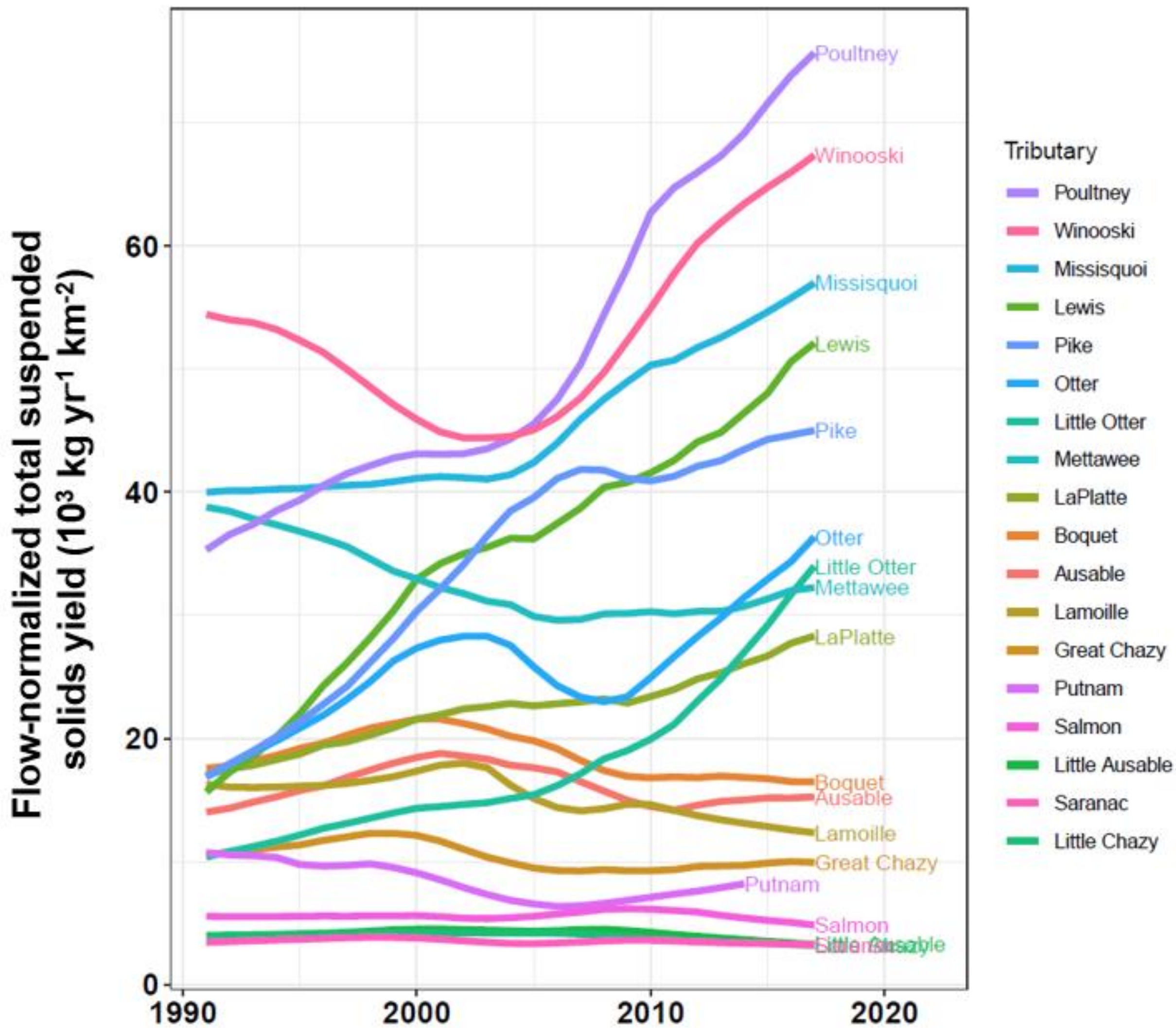


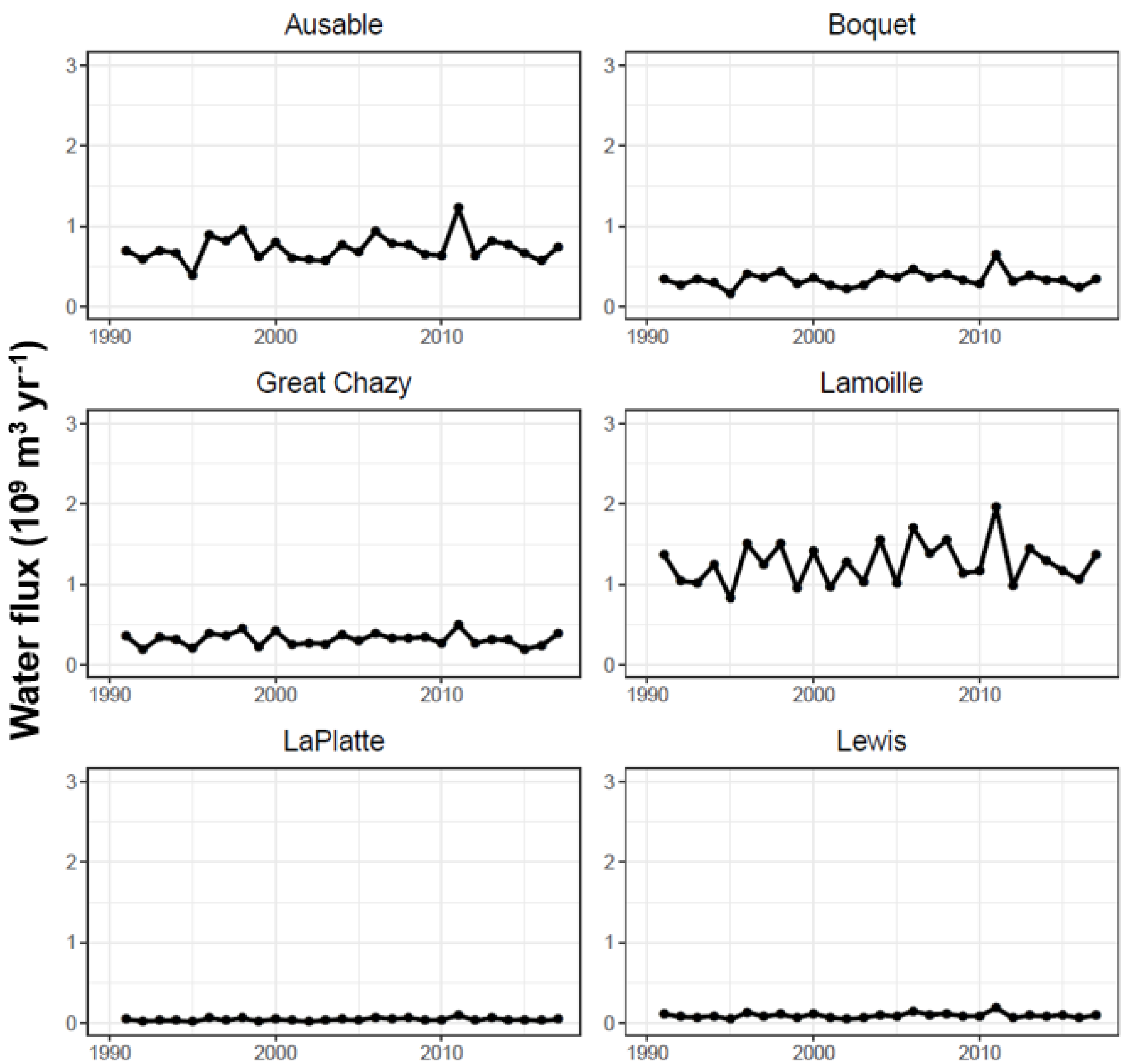
Figure 21. Plot of annual flow-normalized total suspended solids yield estimates for eighteen Lake Champlain tributaries. The flow-normalized yield is an estimate of load per watershed area, with the influence of annual water flux variability reduced. Note that the legend is in descending order by the latest value for each tributary.

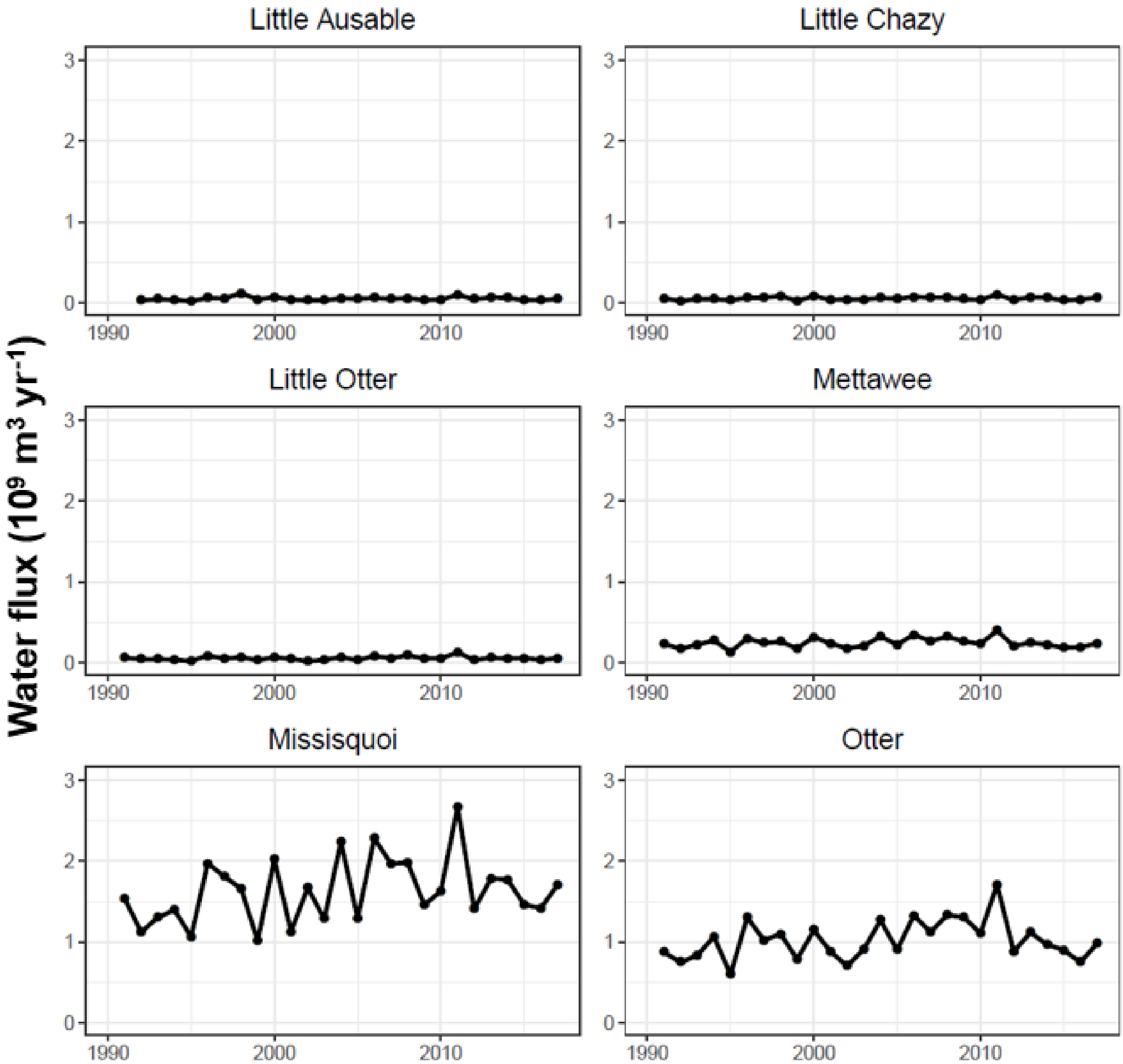
Table 12. Trend probabilities and magnitudes for **flow-normalized total suspended solids load** over three trend periods for eighteen Lake Champlain tributaries. Note that trend periods for ([a]) Putnam Creek end as late as 2013. Significant trends (probability $\geq$ 0.90) are outlined and shown in **bold**.

	First half (1993 to 2004)				Full record (1993 - 2017)				Second half (2004 to 2017)			
Tributary	Direction	Probability of trend	Change (10^3 kg yr^{-1})	Annualized percent change	Direction	Probability of trend	Change (10^3 kg yr^{-1})	Annualized percent change	Direction	Probability of trend	Change (10^3 kg yr^{-1})	Annualized percent change
Ausable	No trend	0.70	3461	1.7	No trend	0.79	479	0.1	No trend	0.67	-2982	-1.2
Boquet	No trend	0.72	1399	1.0	No trend	0.52	-1191	-0.4	No trend	0.70	-2591	-1.5
Great Chazy	No trend	0.60	-671	-0.9	No trend	0.60	-652	-0.4	No trend	0.65	19	0.0
Lamoille	No trend	0.52	349	0.1	**Decrease**	**0.91**	-6543	-1.1	No trend	0.84	-6892	-2.1
LaPlatte	No trend	0.82	581	2.3	**Increase**	**0.94**	1213	2.0	No trend	0.87	632	1.7
Lewis	**Increase**	**0.99**	3537	6.3	**Increase**	**0.97**	6709	4.4	No trend	0.89	3172	2.8
Little Ausable	No trend	0.64	60	0.7	No trend	0.79	-137	-0.9	**Decrease**	**0.97**	-197	-2.3
Little Chazy	No trend	0.55	19	0.3	No trend	0.89	-111	-1.0	**Decrease**	**0.97**	-130	-2.1
Little Otter	No trend	0.89	578	2.8	**Increase**	**0.99**	3370	4.7	**Increase**	**0.97**	2792	6.4
Mettawee	No trend	0.72	-3020	-1.8	No trend	0.65	-2420	-0.7	No trend	0.62	600	0.3
Missisquoi	No trend	0.60	2808	0.3	**Increase**	**0.92**	37110	1.5	No trend	0.89	34303	2.5
Otter	**Increase**	**0.92**	14117	3.5	No trend	0.87	28442	2.8	No trend	0.65	14325	2.2
Pike	**Increase**	**0.99**	11392	6.6	**Increase**	**0.97**	15211	3.7	No trend	0.60	3820	1.2
Poultney	No trend	0.75	3360	1.6	No trend	0.78	18556	3.0	No trend	0.87	15196	4.2
Putnam[a]	No trend	0.70	-485	-3.8	No trend	0.60	-348	-1.4	No trend	0.84	137	1.6
Salmon	No trend	0.55	-17	-0.2	No trend	0.74	-115	-0.6	No trend	0.77	-98	-0.9
Saranac	No trend	0.65	-348	-0.6	No trend	0.62	-526	-0.4	No trend	0.55	-178	-0.3
Winooski	No trend	0.79	-25022	-1.7	No trend	0.90	36760	0.9	**Increase**	**0.96**	61782	3.2

Water

Annual water fluxes for Lake Champlain tributaries were closely related to contributing watershed area (Table *1*, Figure *22*). The highest observed water flux was from the Winooski River in 2011, when 3.0 billion cubic meters of water were delivered to the Lake. There were no trends in water flux for the full record or for the first half record for any tributary. For the second half of record, the Boquet, Mettawee, Otter, Poultney Rivers and Putnam Creek showed significant decreases in annual water flux (Table 13). Plotting mean annual water yield vs. contributing watershed area shows that tributaries with larger watersheds generally had greater runoff per land area (Figure 24).




Little Ausable
Little Chazy
Little Otter
Mettawee
Missisquoi
Otter
Water flux (10⁹ m³ yr⁻¹)
0
1
2
3
1990
2000
2010

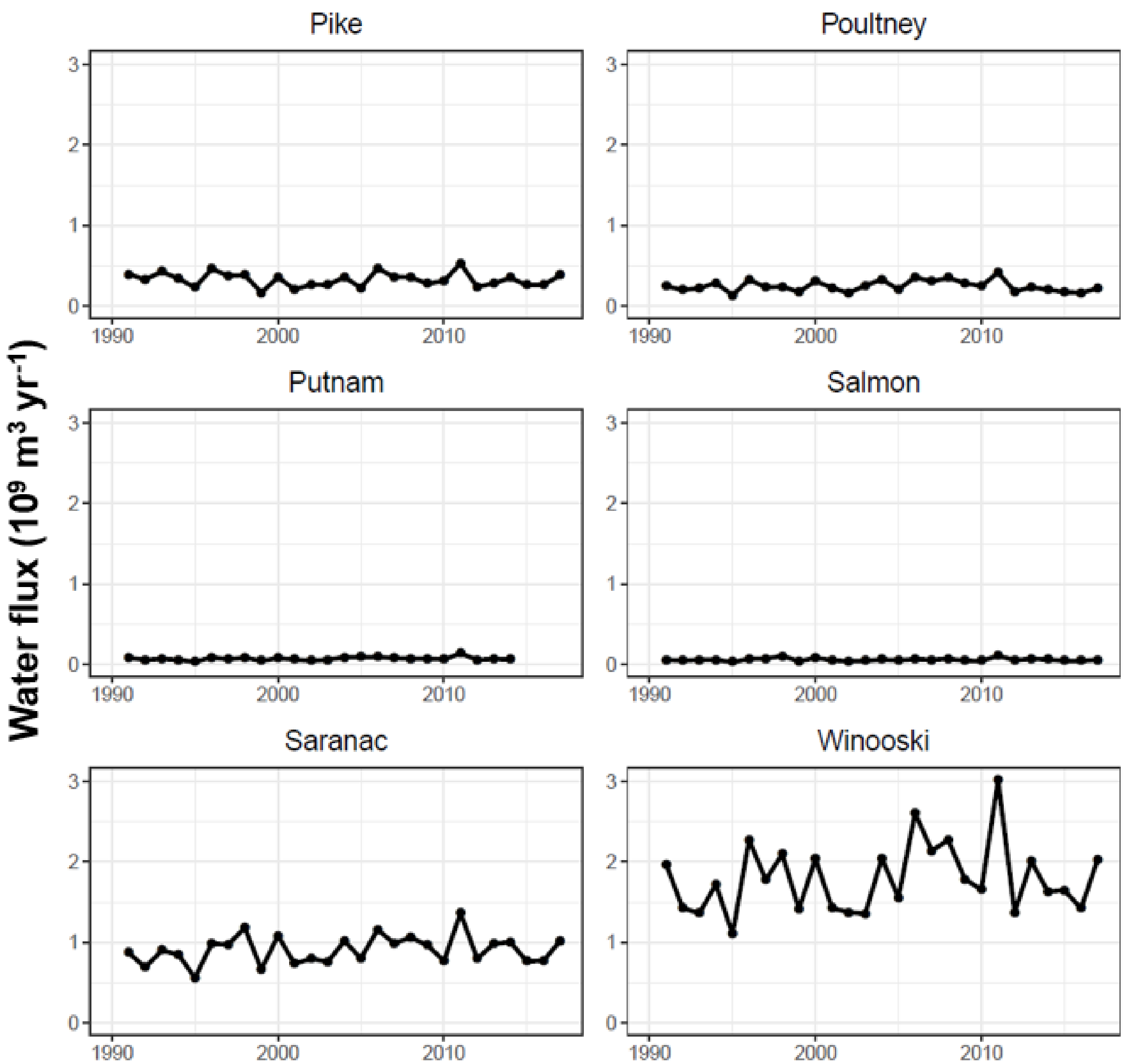
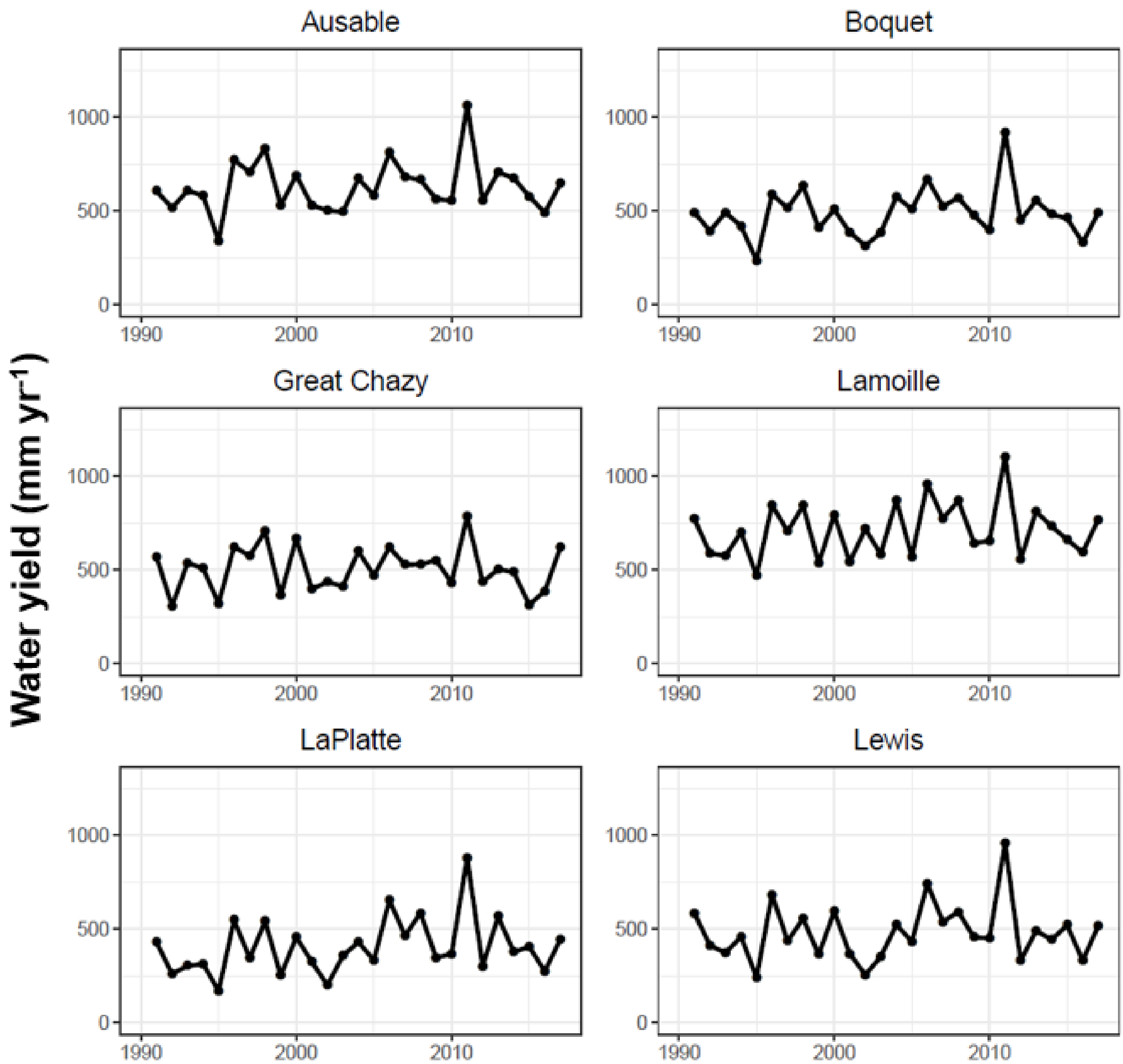
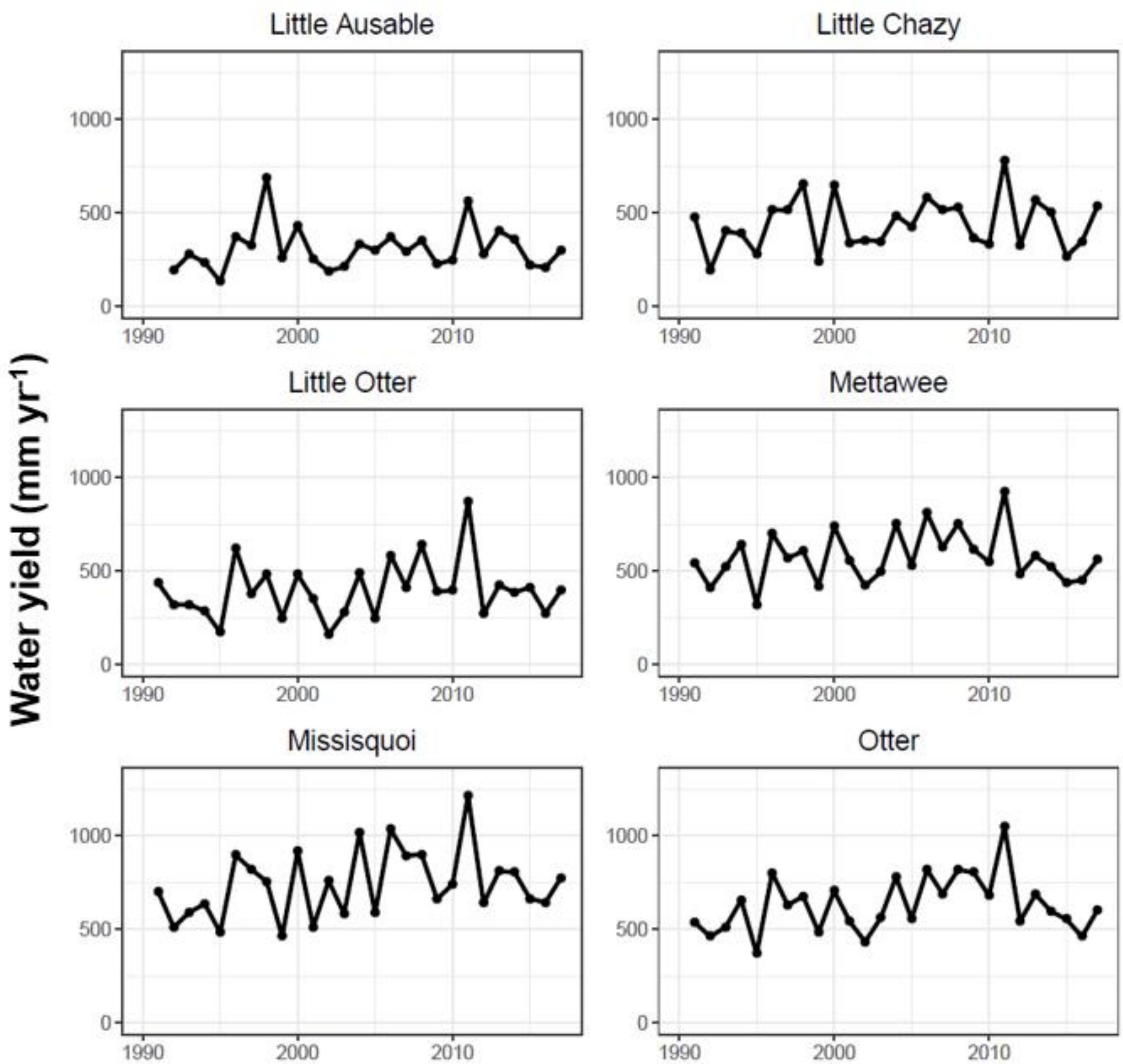


Figure 22. Estimated annual water flux for eighteen Lake Champlain tributaries.


Water yield (mm yr⁻¹)
Ausable
Boquet
Great Chazy
Lamoille
LaPlatte
Lewis
0
500
1000
1990
2000
2010


Water yield (mm yr^{-1})
Little Ausable
Little Chazy
Little Otter
Mettawee
Missisquoi
Otter
0
500
1000
1990
2000
2010

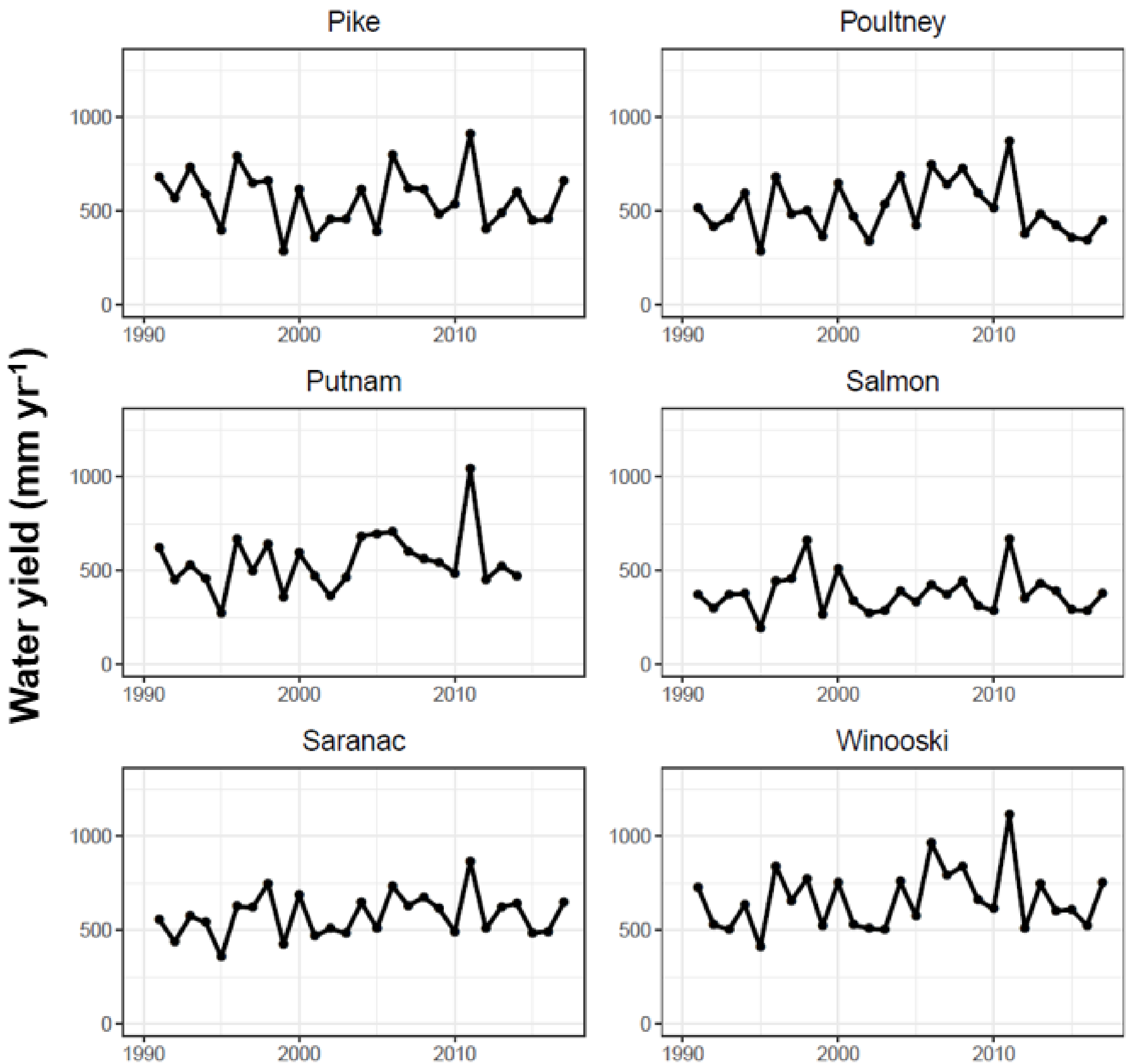


Figure 23. Estimated annual water yield for eighteen Lake Champlain tributaries.

Table 13. Results of Mann-Kendall tests and Sens slope estimator calculations for **annual water flux** over three trend periods for eighteen Lake Champlain tributaries. Note that trend periods for ([a]) Putnam Creek end as late as 2014, and trend periods for ([*]) Little Ausable River begin as early as 1992. Significant trends ($p \leq 0.10$) are outlined and shown in **bold**.

	First half (1991 to 2004)				Full record (1991 - 2017)				Second half (2004 to 2017)			
Tributary	Direction	p value	Sen slope (10^6 m^3 yr^{-1})	Ratio of Sens slope to mean value (%)	Direction	p value	Sen slope (10^6 m^3 yr^{-1})	Ratio of Sens slope to mean value (%)	Direction	p value	Sen slope (10^6 m^3 yr^{-1})	Ratio of Sens slope to mean value (%)
Ausable	No trend	0.66	-5.8	-0.8	No trend	0.90	1.1	0.2	No trend	0.27	-9.8	-1.3
Boquet	No trend	0.83	-1.0	-0.3	No trend	0.77	0.9	0.3	**Decrease**	**0.08**	-7.3	-2.0
Great Chazy	No trend	0.58	4.5	1.4	No trend	0.93	-0.2	0.0	No trend	0.23	-7.0	-2.1
Lamoille	No trend	0.58	6.1	0.5	No trend	0.40	5.3	0.4	No trend	0.38	-19.0	-1.4
LaPlatte	No trend	0.66	0.4	0.9	No trend	0.12	0.5	1.1	No trend	0.58	-0.6	-1.1
Lewis	No trend	0.44	-1.1	-1.2	No trend	0.80	0.3	0.3	No trend	0.32	-1.6	-1.5
Little Ausable*	No trend	0.76	0.6	1.1	No trend	0.66	0.3	0.5	No trend	0.32	-1.0	-1.9
Little Chazy	No trend	0.74	0.9	1.7	No trend	0.59	0.3	0.5	No trend	0.51	-1.0	-1.6
Little Otter	No trend	1.00	-0.2	-0.3	No trend	0.50	0.4	0.7	No trend	0.44	-0.9	-1.4
Mettawee	No trend	0.38	3.4	1.4	No trend	0.68	0.5	0.2	**Decrease**	**0.03**	-9.3	-3.5
Missisquoi	No trend	0.32	33.7	2.2	No trend	0.16	13.6	0.8	No trend	0.27	-34.7	-1.9
Otter	No trend	0.38	14.6	1.5	No trend	0.20	5.9	0.6	**Decrease**	**0.08**	-31.8	-2.8
Pike	No trend	0.23	-6.8	-2.1	No trend	0.50	-1.8	-0.5	No trend	0.58	-3.1	-0.9
Poultney	No trend	0.51	3.3	1.4	No trend	0.80	-0.5	-0.2	**Decrease**	**0.02**	-13.1	-5.0
Putnam[a]	No trend	0.91	0.1	0.1	No trend	0.47	0.3	0.4	**Decrease**	**0.03**	-3.5	-4.2
Salmon	No trend	0.74	0.3	0.4	No trend	1.00	0.0	0.0	No trend	0.44	-0.7	-1.1
Saranac	No trend	0.58	10.9	1.3	No trend	0.26	4.6	0.5	No trend	0.38	-6.0	-0.6
Winooski	No trend	0.83	-1.7	-0.1	No trend	0.50	7.7	0.4	No trend	0.23	-36.2	-1.9

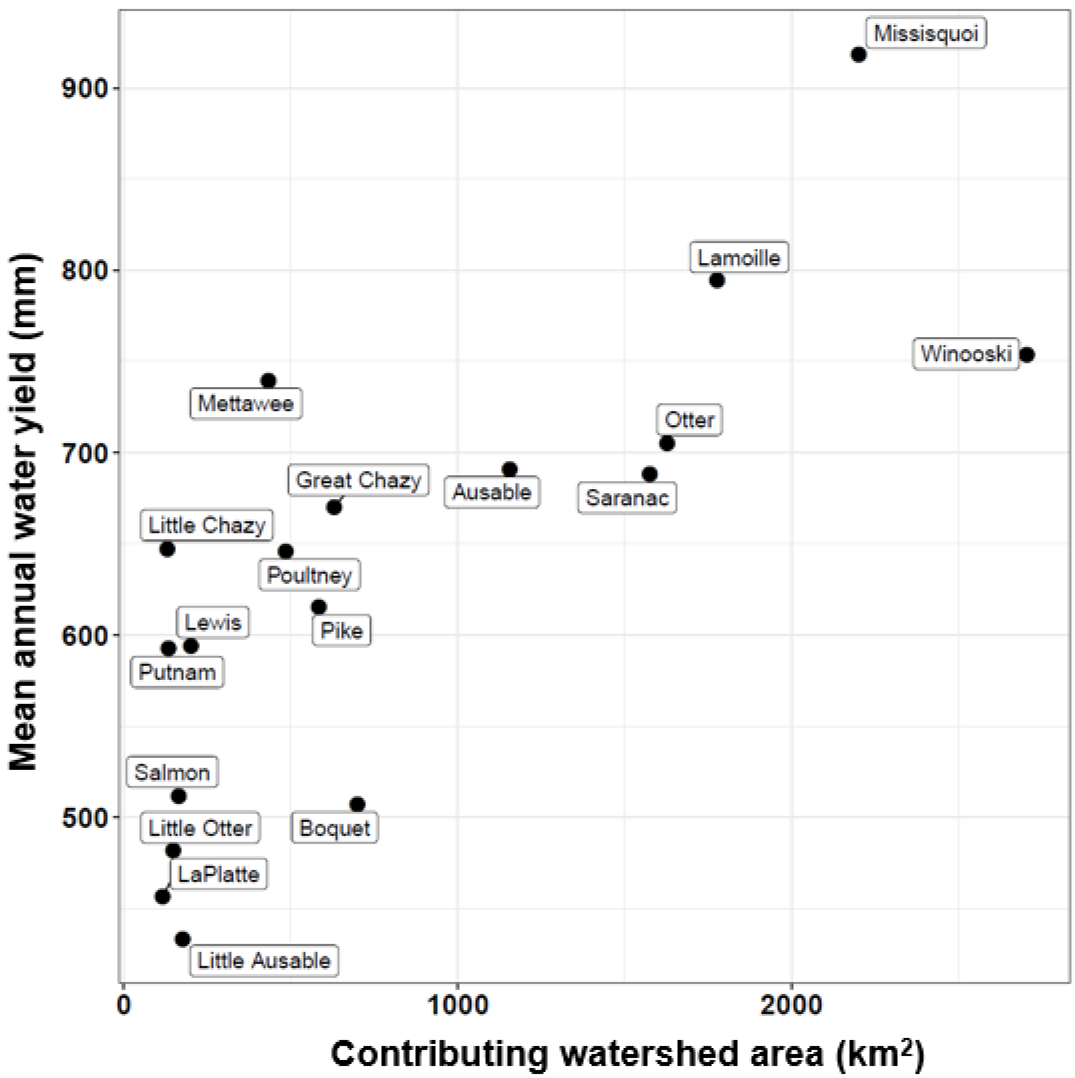


Figure 24. Plot of the mean annual water yield for all years considered in this report versus the contributing watershed area for 18 Lake Champlain tributaries.

Conclusion

Determining tributary concentrations and loads for key water quality parameters will continue to be important as Lake Champlain managers and stakeholders face water quality challenges and work toward shared goals. This report represents observed conditions and trends over the period of record; they do not necessarily represent a trajectory into the future. As in the past, the future delivery of water, nutrients, chloride, and sediment to Lake Champlain will depend on several factors, including climate conditions, pollution reduction practice implementation, management decisions, river geomorphic function, and changes in watershed land use and land cover.

The results of this report demonstrate the tremendous value of the Lake Champlain Long-term Monitoring Program in determining the state of the Lake Champlain ecosystem and changes in this system over time. The Lake Champlain Basin Program plans to continue its support for this monitoring in partnership with New York and Vermont Departments of Environmental Conservation and the New England Interstate Water Pollution Control Commission.

Acknowledgements
This work greatly benefited from conversations with Laura Medalie (USGS), Jennifer Murphy (USGS), Jamie Shanley (USGS), and the Lake Champlain Basin Program team.

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Where have we come from and where are we headed? Technical report on Lake Champlain tributary loading, 1990 – 2017

Lake Champlain Basin Program Technical Report

Matthew C.H. Vaughan, PhD

Presentation for

Lake Champlain Steering Committee

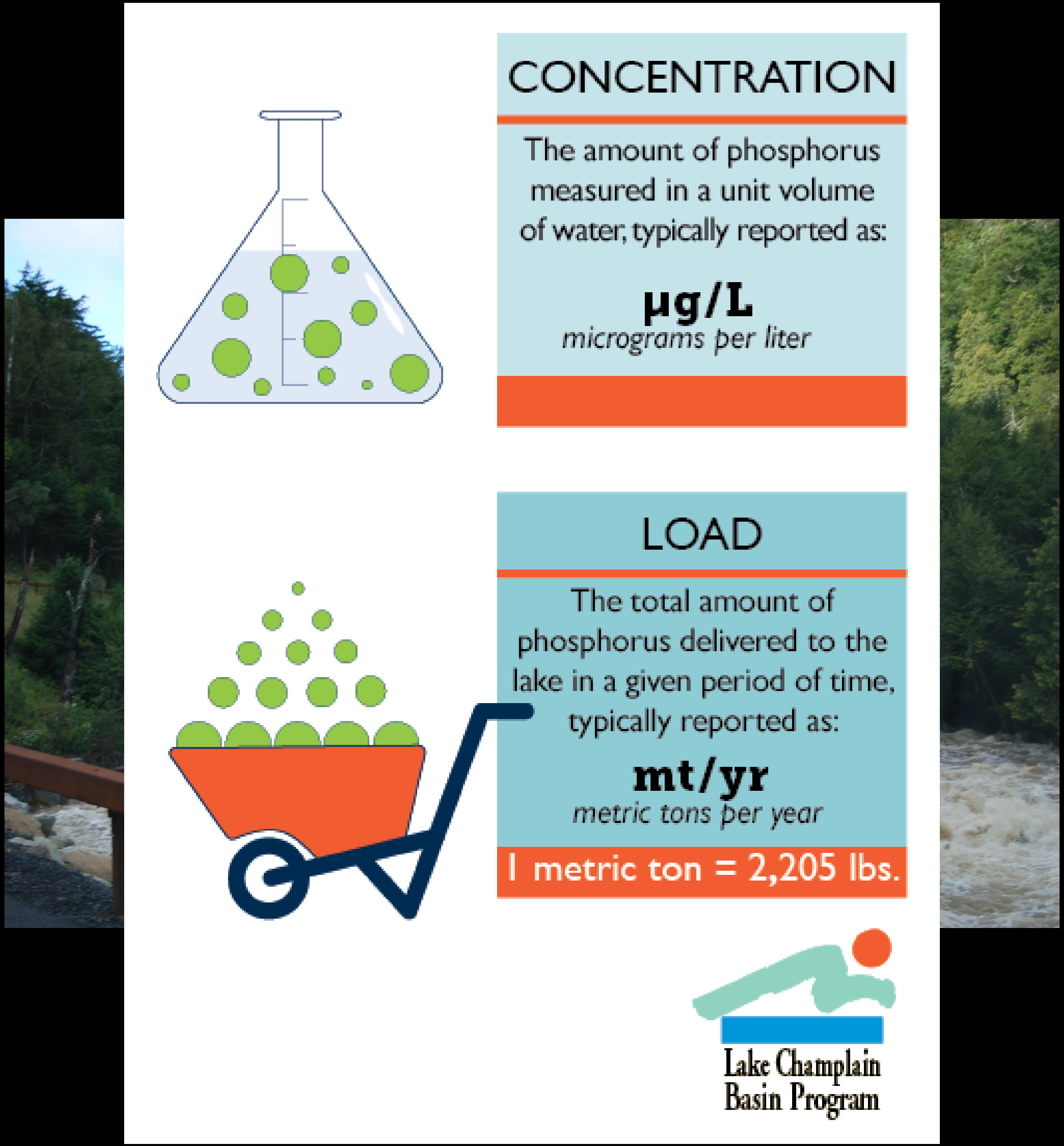
June 6, 2019

NEIWPCC
New England Interstate Water Pollution Control Commission

Lake Champlain Basin Program

Goals

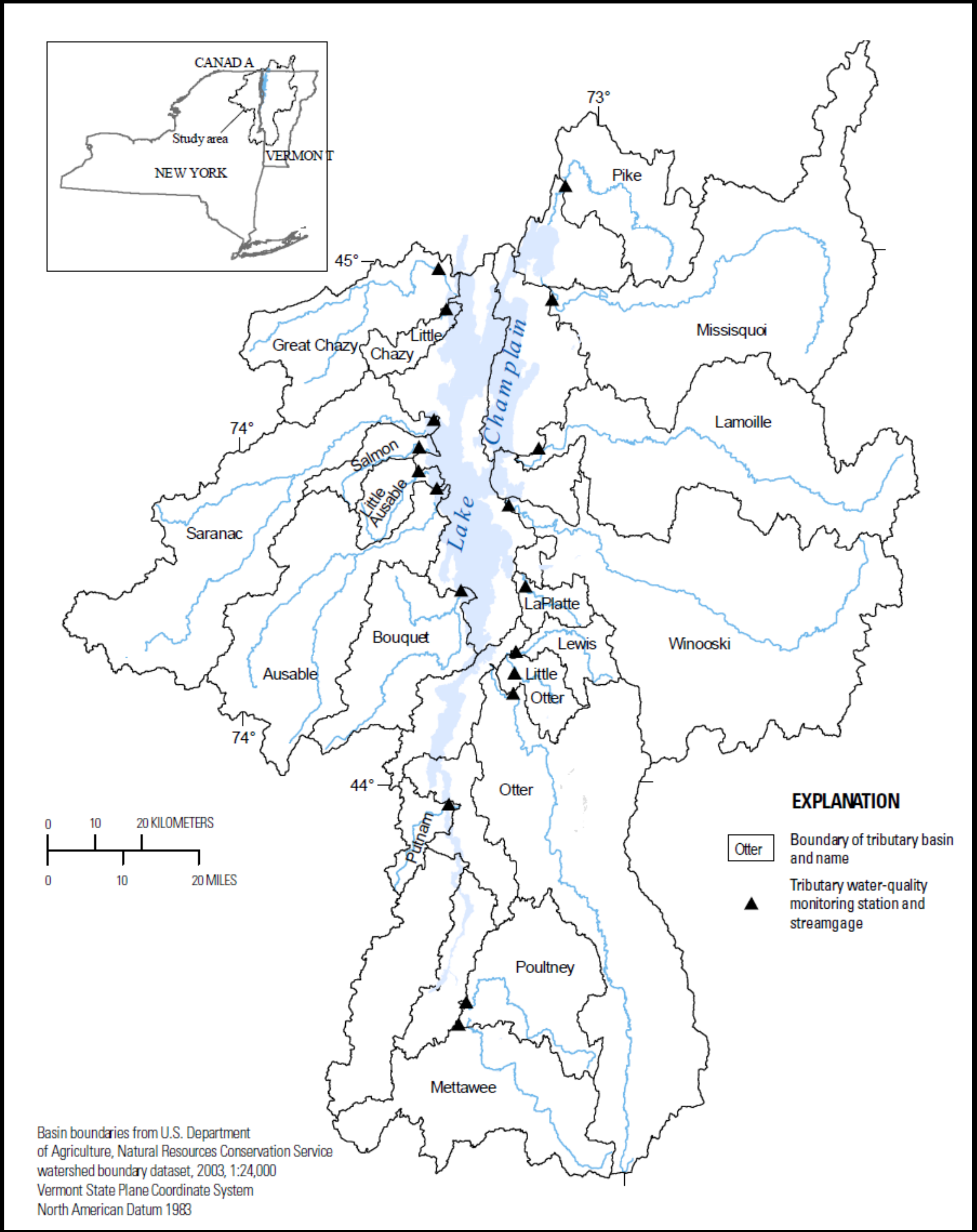
- Phosphorus, nitrogen, chloride, and suspended sediment
    - Concentration
    - Load
    - Trends
- What, not why
- Audience



- Thank you USGS partners
  - Laura Medalie, Jamie Shanley, Jennifer Murphy, Bob Hirsch team
- Several past efforts

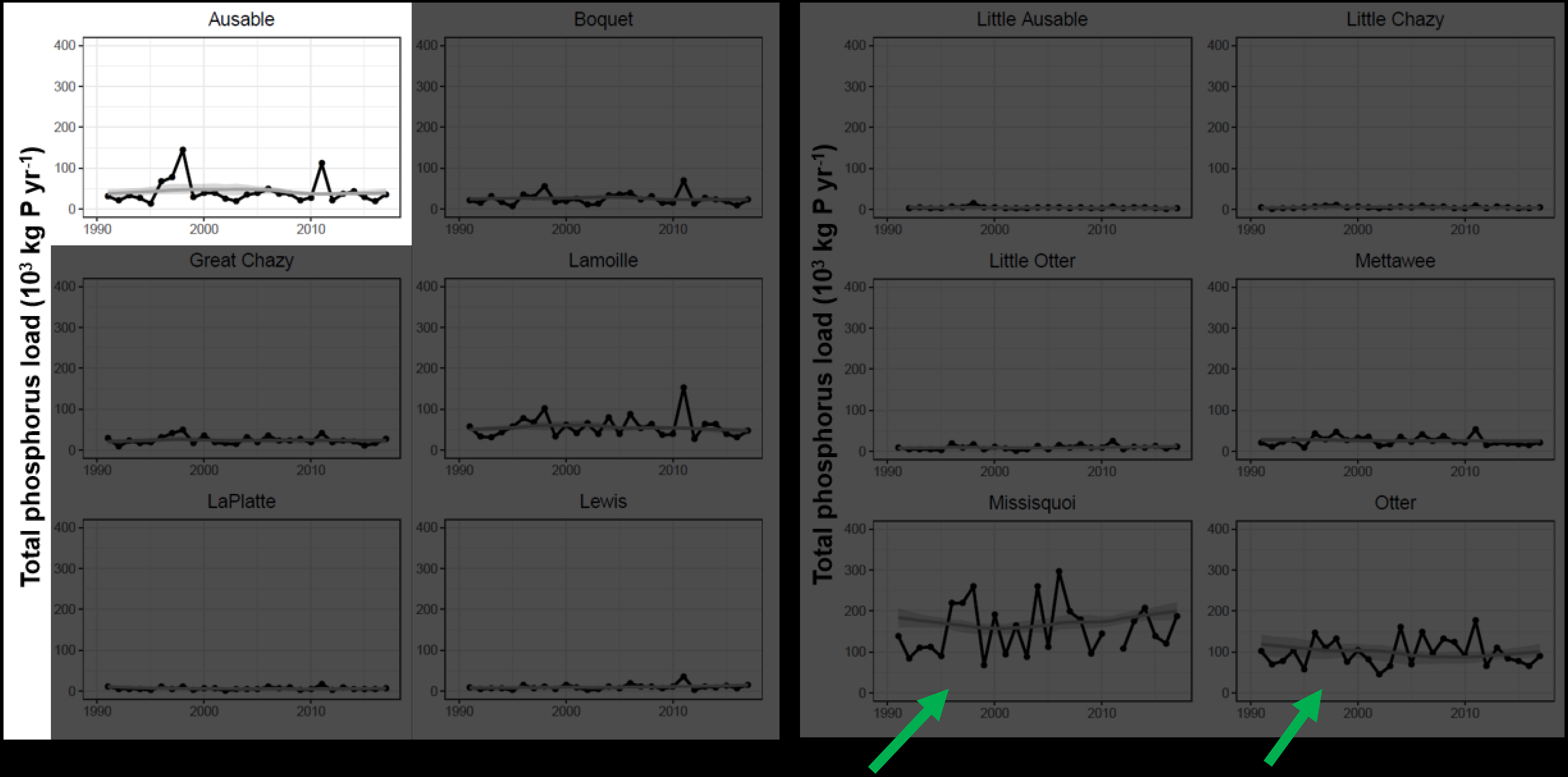
Methods

- 18 tributaries
- Long-term monitoring program samples
- Model to predict concentration -> load
- Reduce influence of annual flow variability
- Probability of trend



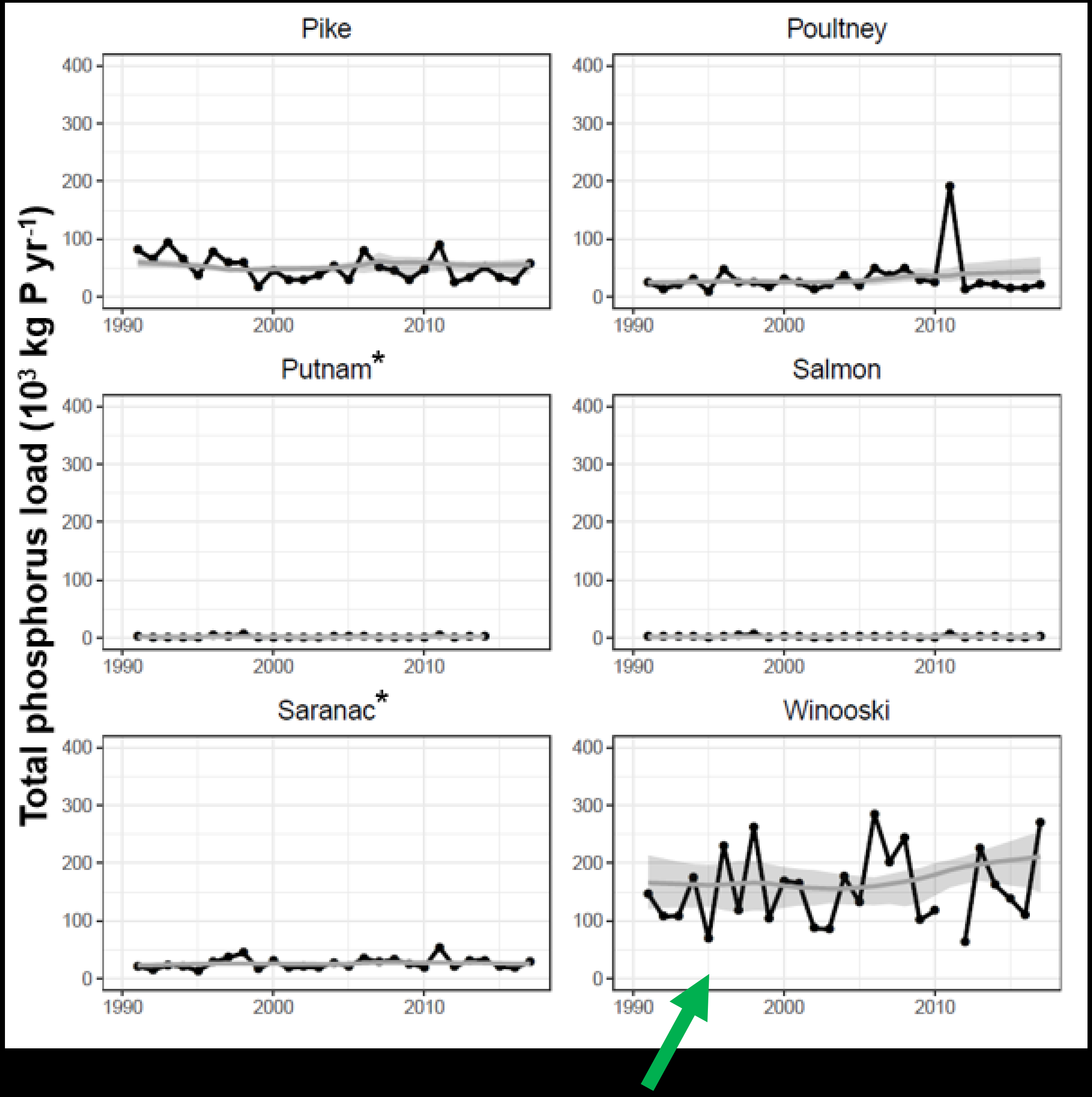
Medalie 2016

World Wildlife
Foundation

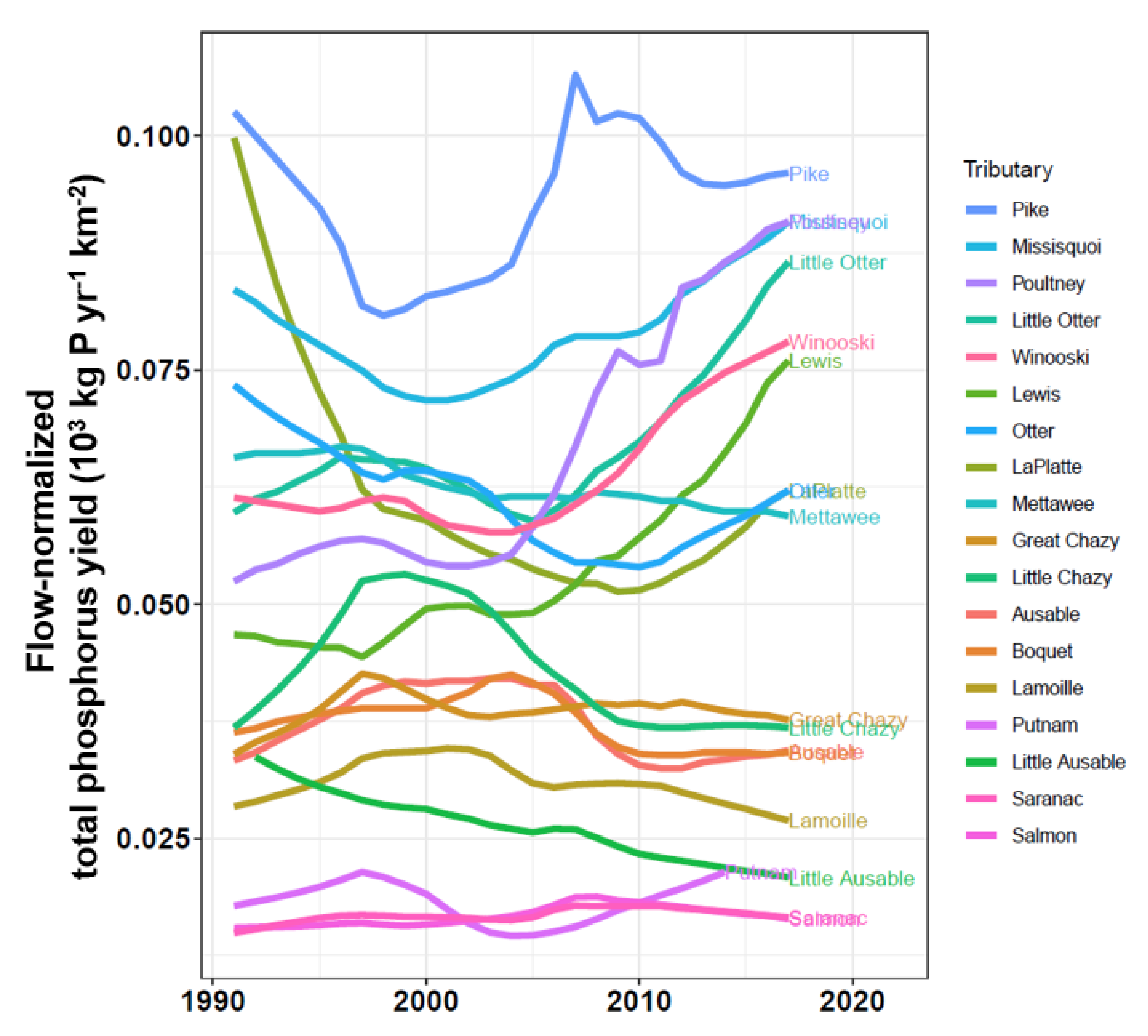


Missisquoi Bay TMDL allocation: 49 mt/yr

Otter Creek TMDL allocation: 107 mt/yr



Main Lake TMDL allocation: 123 mt/yr

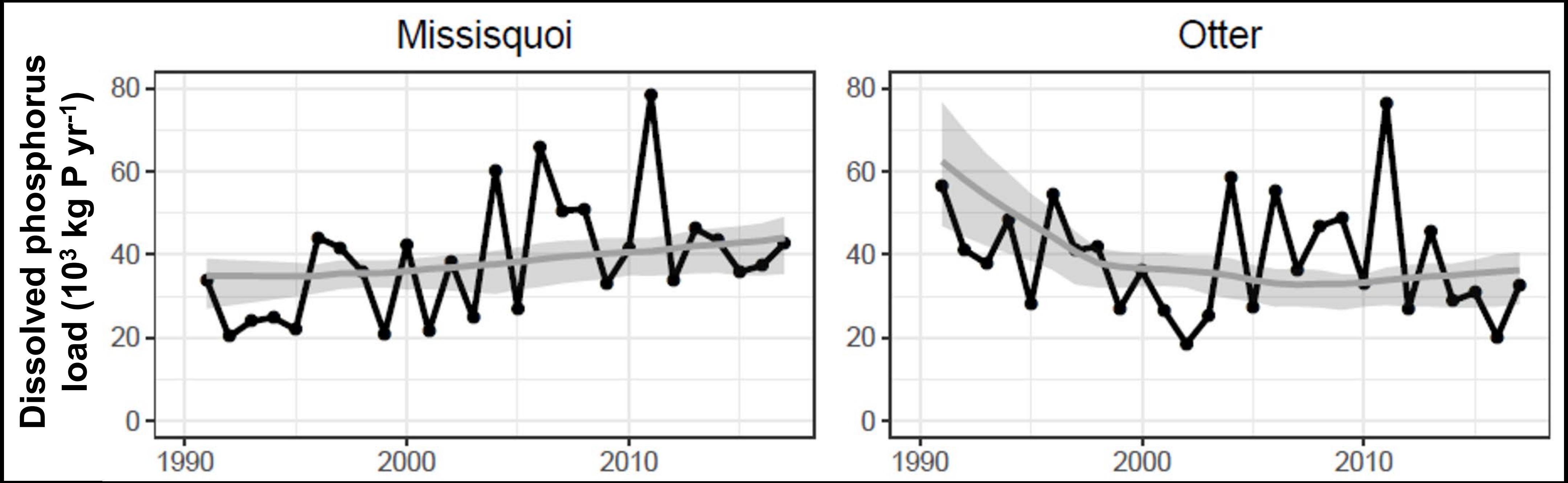


Flow-normalized
total phosphorus yield (10^3 kg P yr^{-1} km^{-2})
0.100
0.075
0.050
0.025
1990
2000
2010
2020
Pike
Little Otter
Winooski
Lewis
Mettawee
Lamoille
Little Ausable
Tributary
Pike
Missisquoi
Poultney
Little Otter
Winooski
Lewis
Otter
LaPlatte
Mettawee
Great Chazy
Little Chazy
Ausable
Boquet
Lamoille
Putnam
Little Ausable
Saranac
Salmon

Total phosphorus takeaways

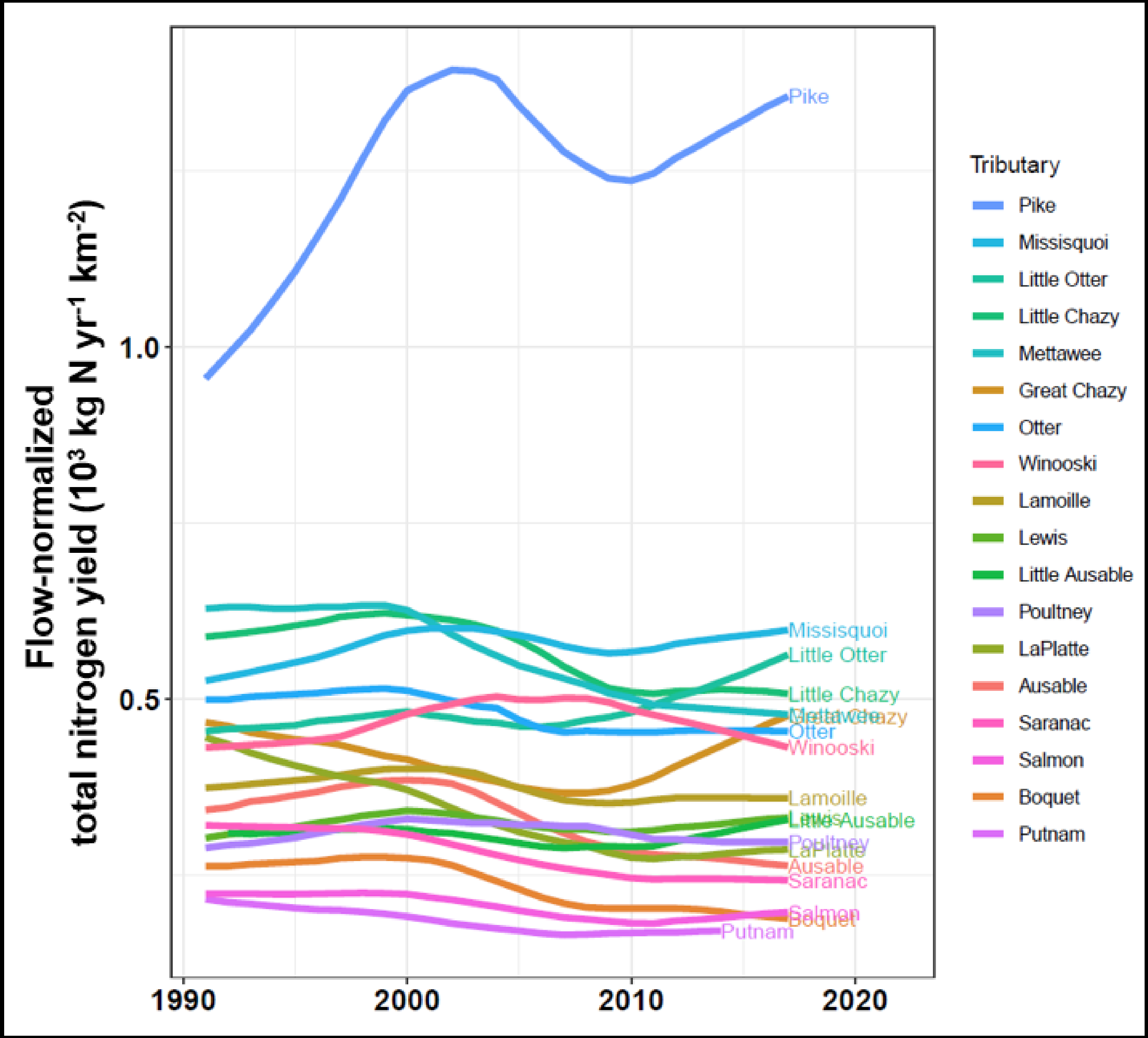
- Highly variable
- No trends in 10 out of 18 tributaries
- Full record decreases in Little Ausable River
- Decreased first half of record in LaPlatte River, but no trend found in second half of record.
- Full record increases: Lewis and Little Otter Creek
- Recent increases: Missisquoi, Poultney, Putnam Putnam

See report for dissolved phosphorus



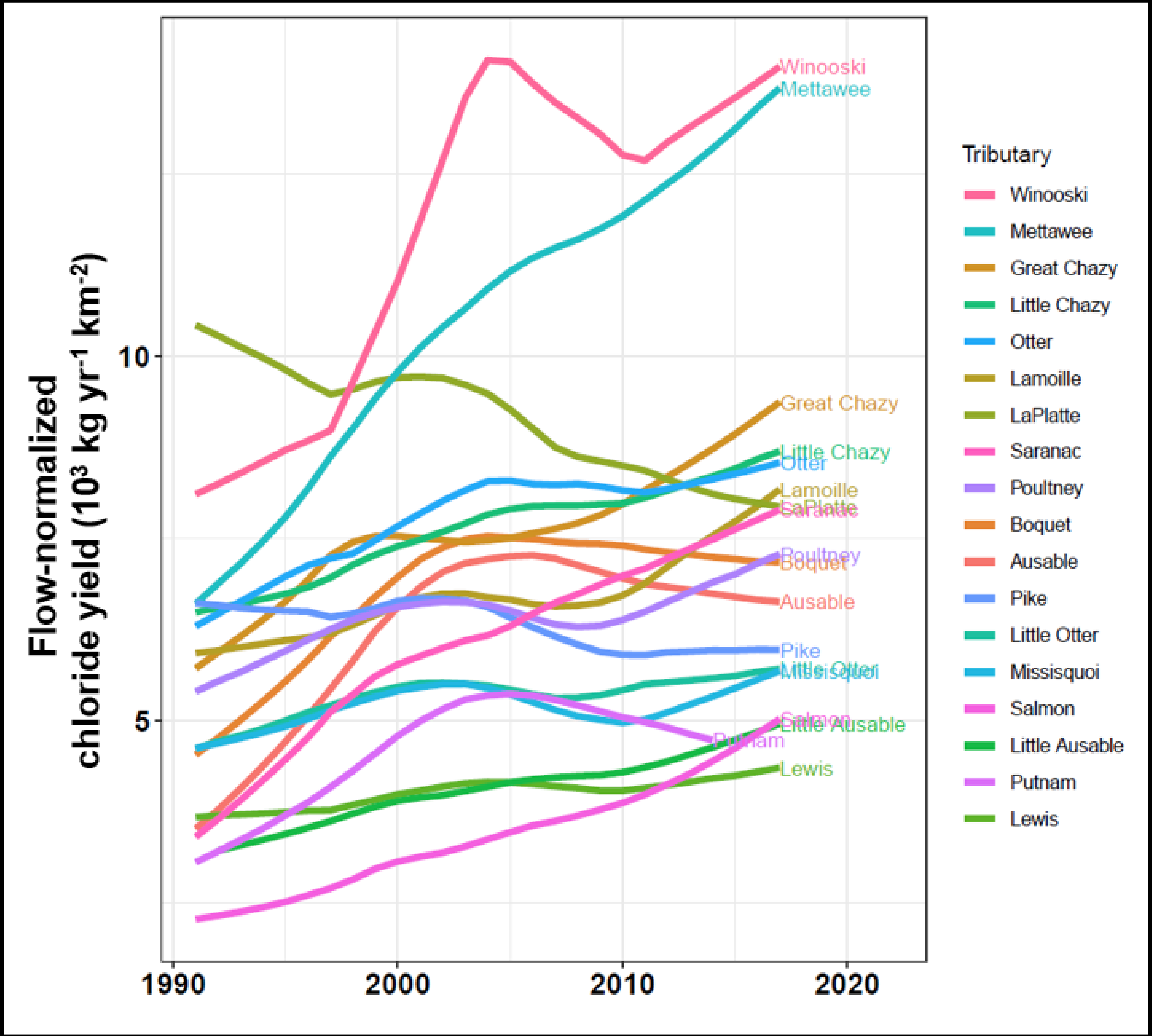
Total nitrogen

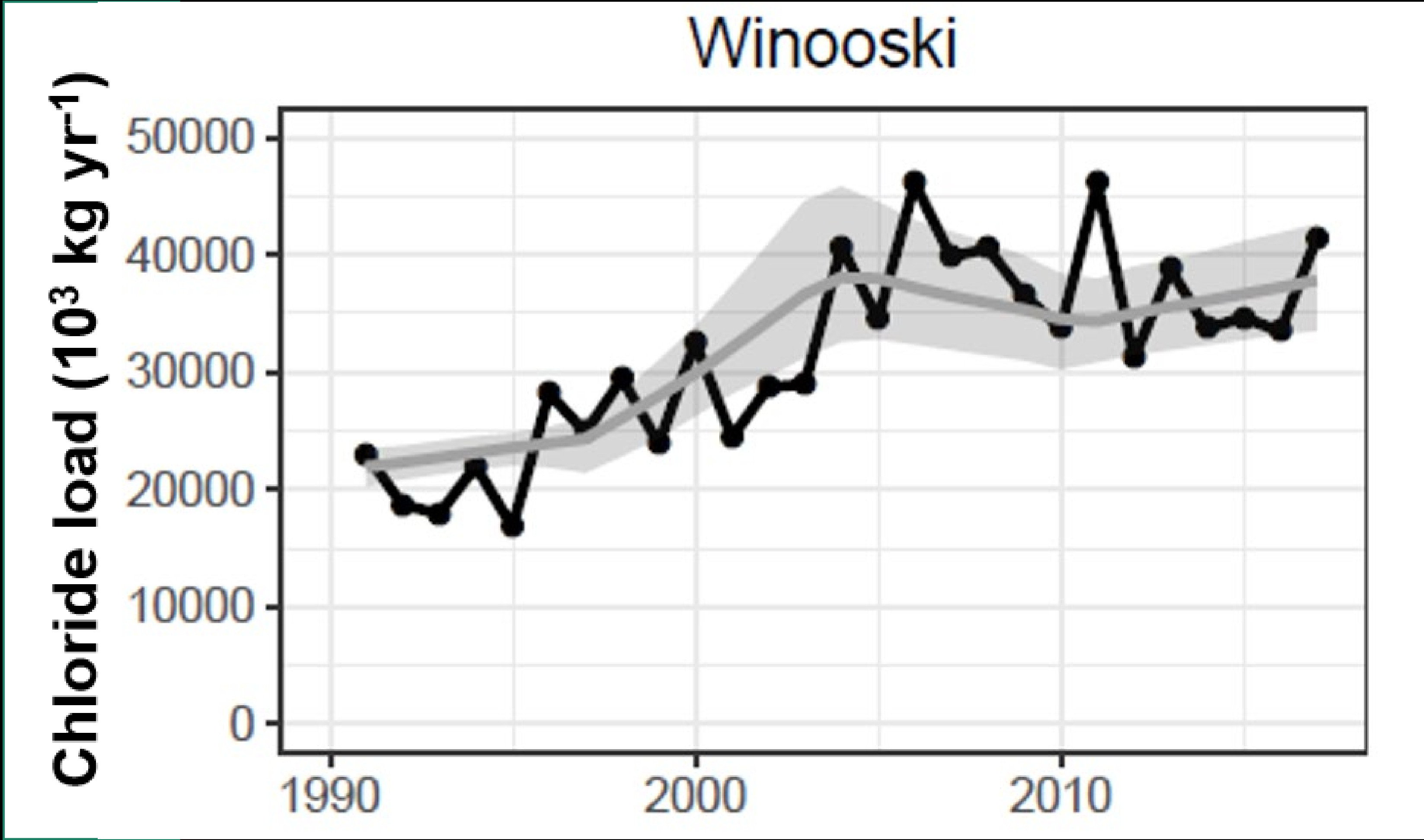
- Pike River yield
- Trends for 15 out of 18 tributaries
- Six tributaries decreased for full record: LaPlatte, Mettawee, Saranac, Salmon, Otter, and Putnam
- Recent decreases: Ausable, Boquet, and Little Chazy
- Recent increases: Great Chazy, Little Otter Creek

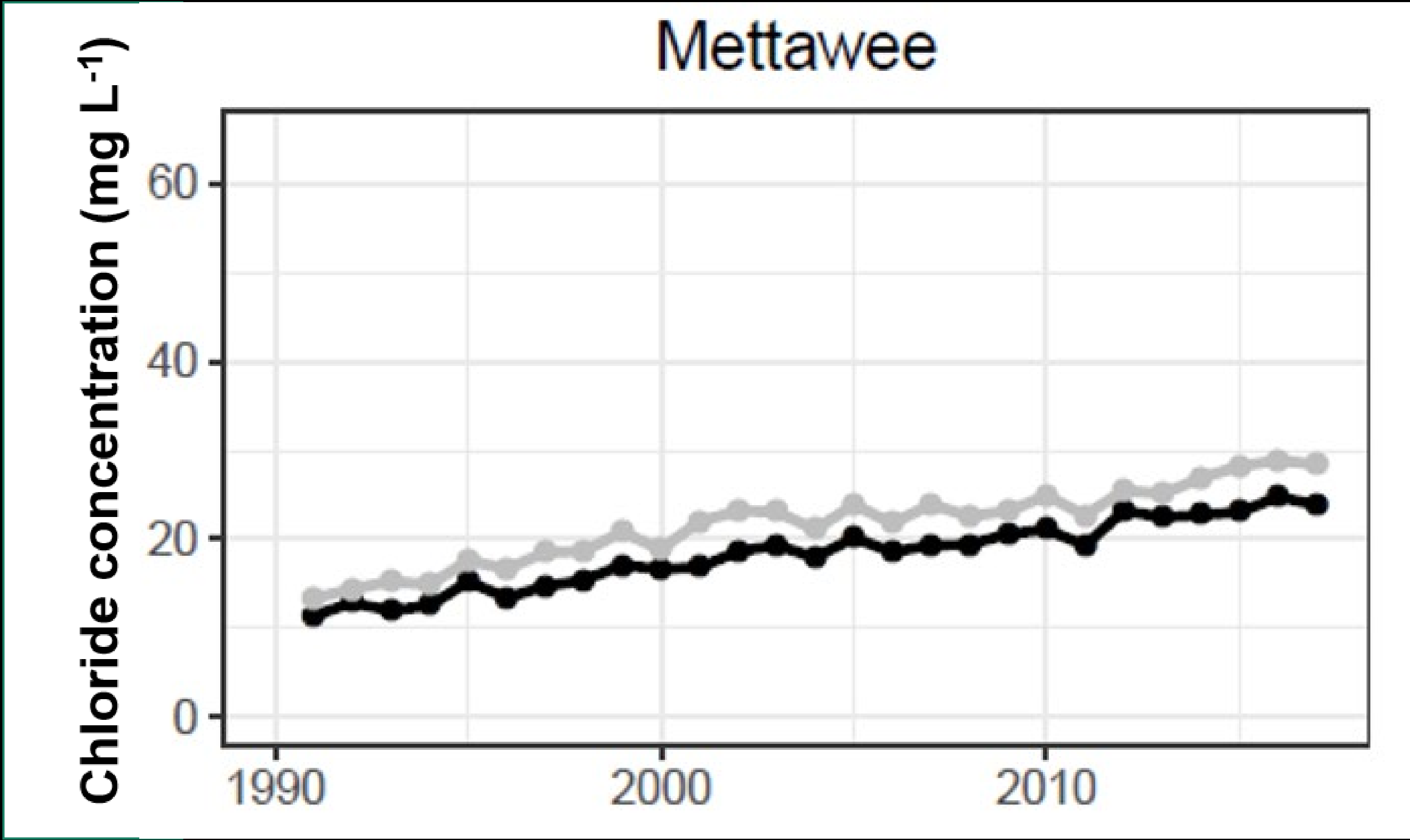


Chloride

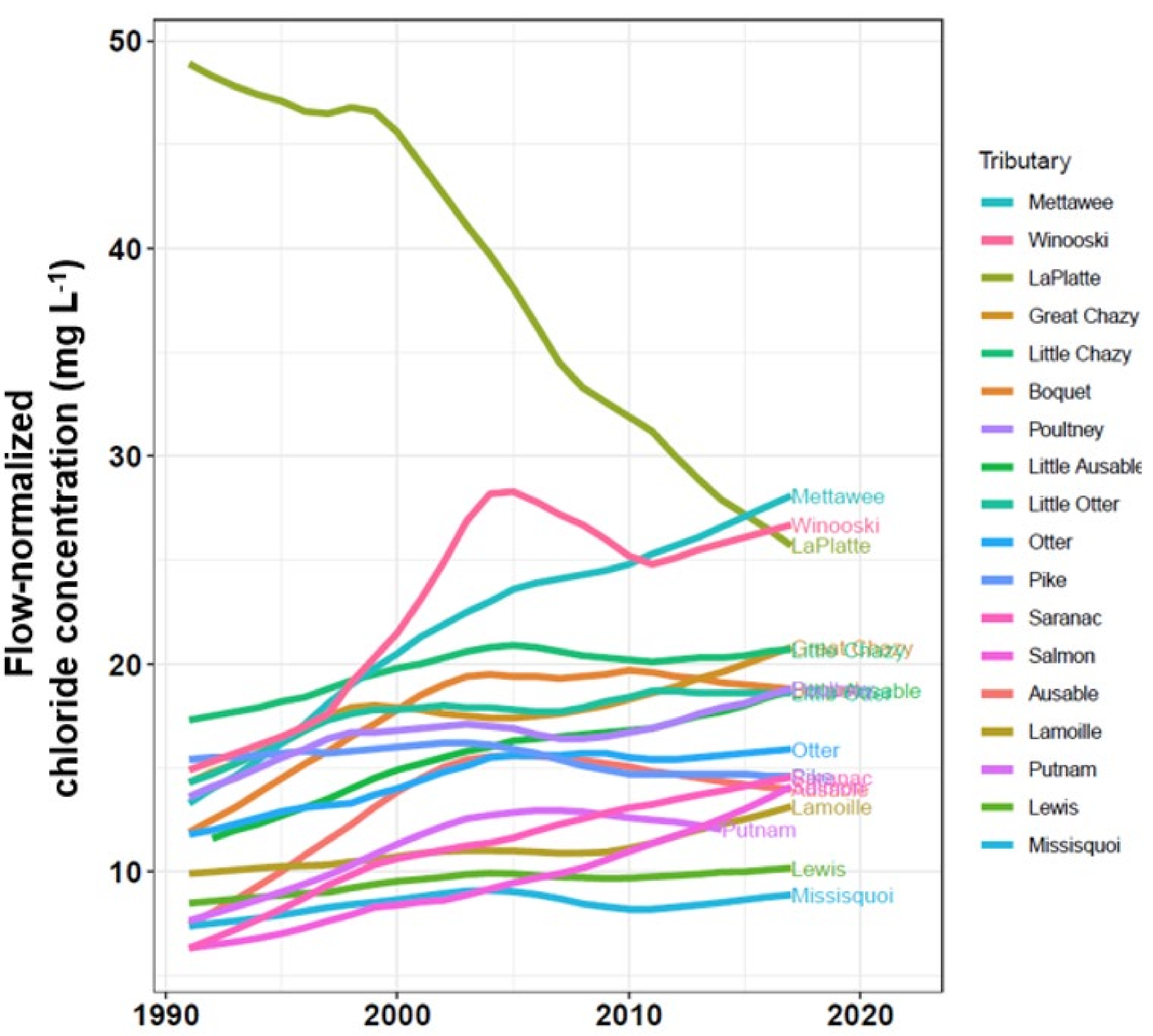
- Winooski and Mettowee
- Full record increasing trends for 16 out of 18 tributaries
- Seven of these tributaries show no trend for second half of record.
- Full record decreases: LaPlatte and Pike




Winooski
Chloride load (10^3 kg yr^-1)
50000
40000
30000
20000
10000
0
1990
2000
2010



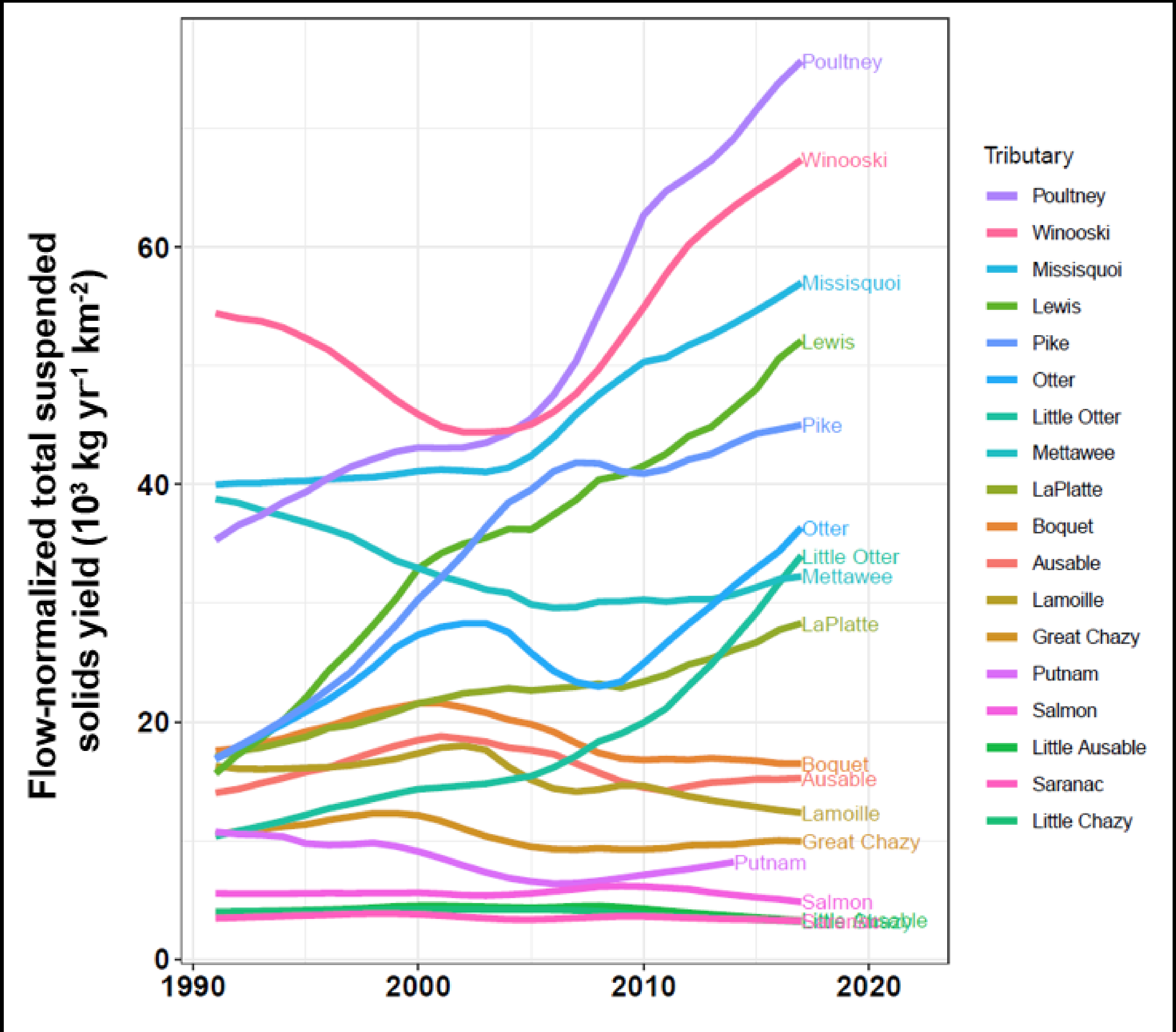
Mettawee
Chloride concentration (mg L-1)
60
40
20
0
1990
2000
2010

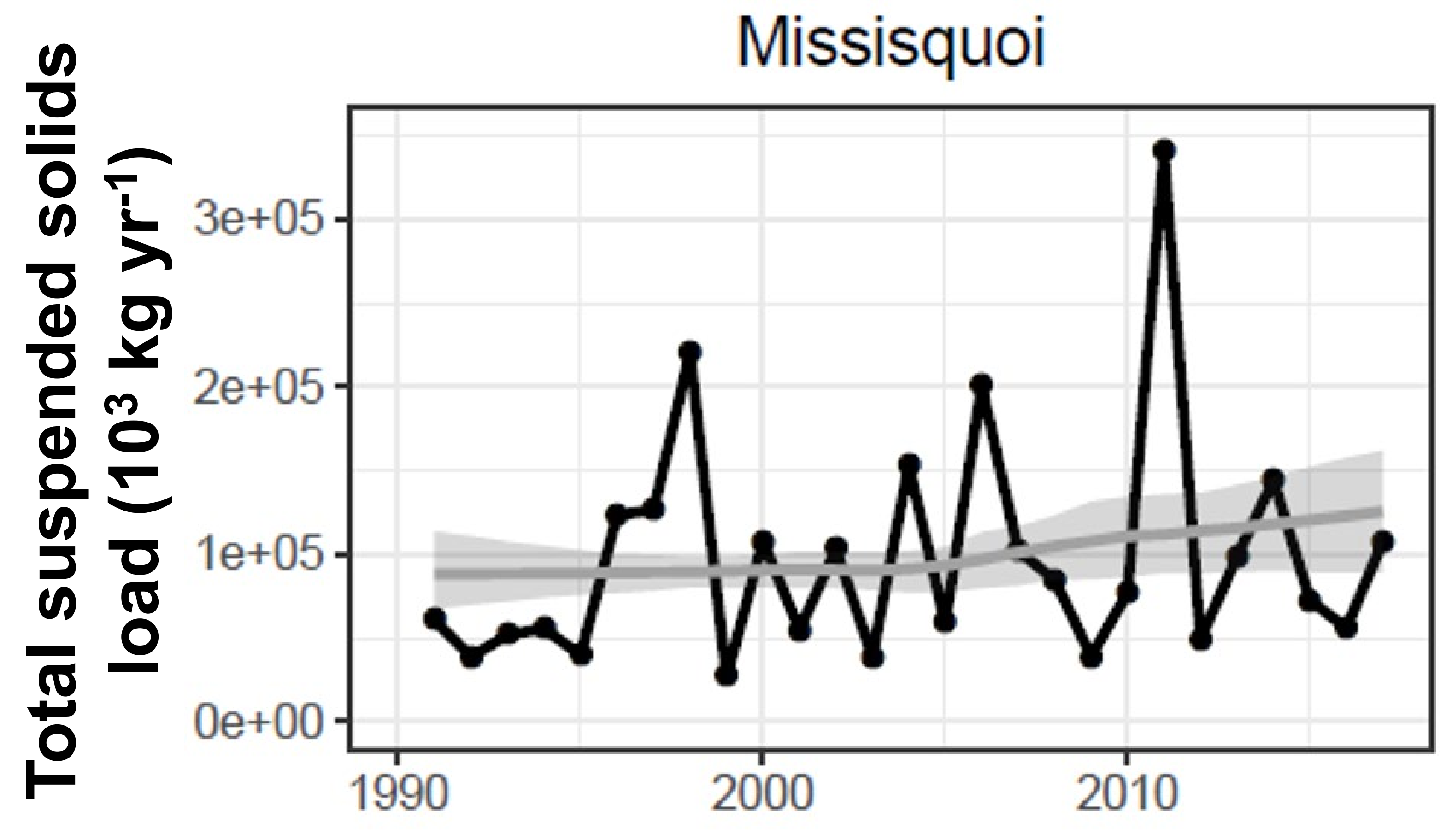


Flow-normalized chloride concentration (mg L-1)
50
40
30
20
10
1990
2000
2010
2020
Tributary
Mettawee
Winooski
LaPlatte
Great Chazy
Little Chazy
Boquet
Poultney
Little Ausable
Little Otter
Otter
Pike
Saranac
Salmon
Ausable
Lamoille
Putnam
Lewis
Missisquoi

Total suspended solids

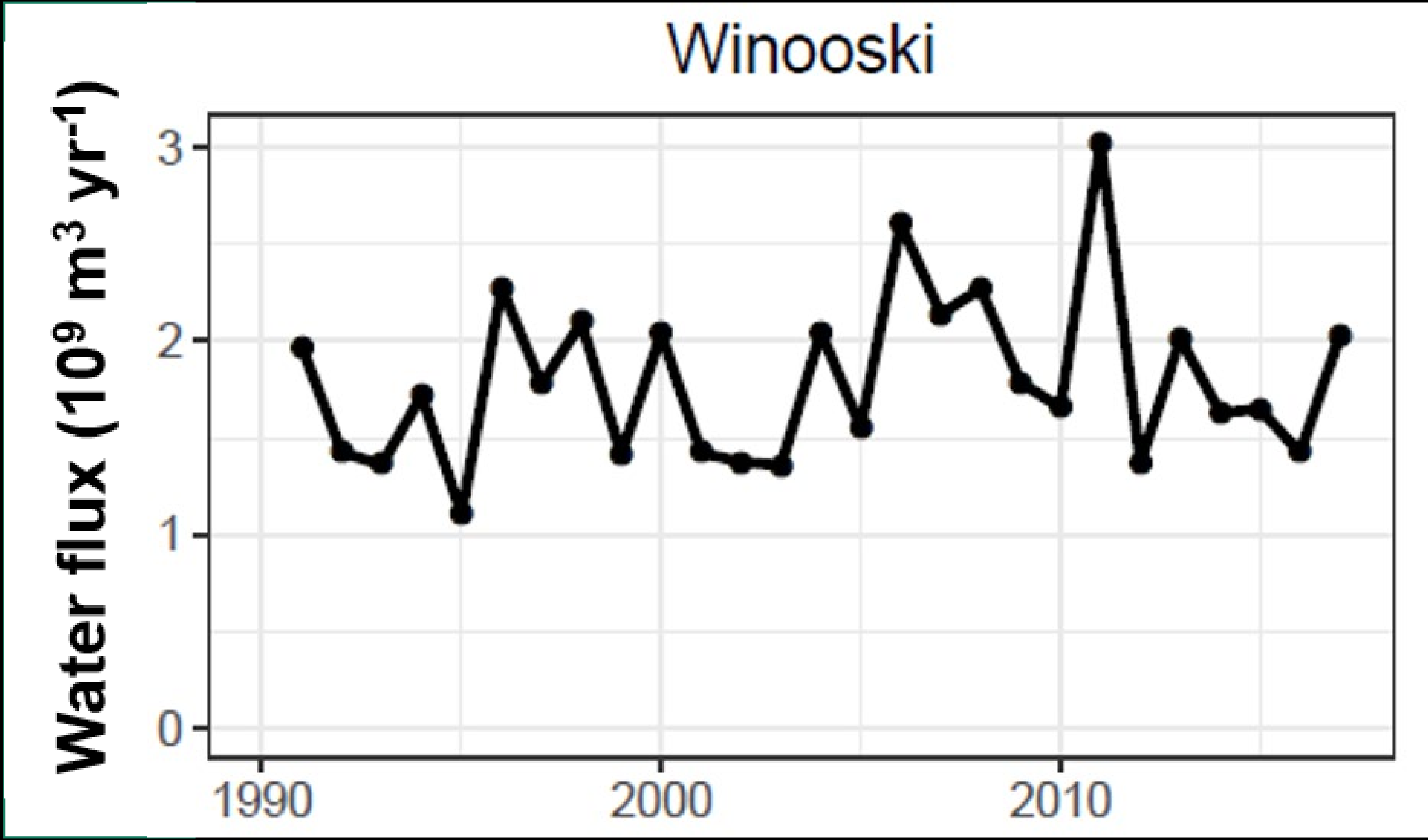
- Major tributaries highly variable (up to 300,000 mt)
- Five tributaries increased full record, only two increased second half of record
- Three tributaries decreased: Lamoille River for full record, and Little Ausable and Little Chazy Rivers for second half of record only




Missisquoi
Total suspended solids load (10³ kg yr⁻¹)
3e+05
2e+05
1e+05
0e+00
1990
2000
2010

Water

- Closely related to watershed area
- No full record or first half trends
- Five decreases in second half of record: Boquet, Mettawee, Otter, Poultney, Putnam
- Yield increased with watershed area



Winooski
Water flux (10^9 m^3 yr^-1)
0
1
2
3
1990
2000
2010

Plain language takeaways

- Loading dominated by hydrologic variability
- **<u>Total phosphorus:</u>** Several with no trends, two decreases, a few recent increases.
- **<u>Nitrogen:</u>** Many trends, mostly decreasing though some have increased.

Plain language takeaways

- **Chloride:** Nearly all had historic increases, some increases have slowed or stopped.
- **Total suspended solids:** Several with no trends, some historic increases have slowed or stopped.
- **Water:** Few trends, though some tributaries have delivered less water in recent years.

Find the report at: bit.ly/2wDAQ17

VERMONT
AGENCY OF NATURAL RESOURCES

Vermont Agency of Natural Resources Update
Lake Champlain Basin Program Steering Committee Meeting
June 6, 2019

Legislative Updates

- The Vermont General Assembly has passed S. 96, which is an **act that redesigns how water quality services and projects are delivered**, and importantly, establishes, as of January 1, 2020, **a long-term funding source** for Clean Water in Vermont by directing six percent of the Vermont Rooms and Meals (R+M) Tax into the Clean Water Fund. This is expected to raise $7.5M in SFY 2020 and at least $12M annually for the fund, plus inflation, in subsequent years. This is in addition to the $7M annually Vermont has previously committed to clean water. The R+M tax is projected to grow at an average rate of 3.4% per year over the next five years, meaning, inflationary pressures on the Clean Water Fund will be addressed by this funding source.

- The Vermont General Assembly passed S. 49, an **Act requiring the regulation of PFAS compounds** in Vermont. Among other requirements, the law requires that DEC adopt a maximum contaminant limit for PFAS in the Vermont water supply regulations and establish and execute a plan to adopt a surface water criteria for PFAS by 2023.

Clean Water Budget

- The **Clean Water Board** will revise its SFY 2020 clean water budget based on the outcomes of the Legislative Session, including S.96. The Clean Water Board initiates its SFY 2021 clean water budget process at its June 12, 2019 public meeting. The budget process will include opportunities for public comment.

Rule Changes

- The **Investigation and Remediation of Contaminated Properties Rule** will be presented to the Legislative Committee for Administrative Rules (LCAR) in June 2019 for final adoption.

- The **Groundwater Protection Rule** will be presented to the Legislative Committee for Administrative Rules (LCAR) in June 2019 for final adoption.

- The **Wastewater System and Potable Water Supply Rules** and **Indirect Discharge Rules** were updated and approved by the Legislative Committee on Administrative Rules. Both rules, which affect more than 50% of properties in Vermont, were formally adopted effective April 12, 2019.

Funding Opportunities and Updates

- The Department of Environmental Conservation has completed a **first SFY 2020 Ecosystem Restoration funding round**, supporting 26 projects for a total of $1.7M. In addition, the department has issued several water quality implementation block grants to support design-implementation, project development, river corridor easements, and woody buffer plantings.

- The Department of Environmental Conservation has awarded a third year of the **Municipal Roads Grants-in-Aid Program** to be administered by Northwest Regional Planning Commission. All 260 of Vermont's municipalities required to comply with the Municipal Roads General Permit will be invited to enroll this spring to access $2.9 million for best management practice construction beginning July 2019. Last year, over 80% of municipalities enrolled in the program.

- The Department of Environmental Conservation is establishing a program to assist **schools to adopt and install Green Stormwater Infrastructure** to support early compliance with requirements of the "Three-acre" stormwater rule. This work is being supported by a mix of Ecosystem Restoration and Chapter 120 funding received through the LCBP FFY19 appropriation.

- The department has initiated a program to support the development of **decentralized in-ground wastewater treatment** to support the many Vermont communities where growth is severely limited by the lack of available wastewater capacity. See https://dec.vermont.gov/village-wastewater.

- The **Clean Water State Revolving Fund** (CWSRF) Federal Fiscal Year 2019 Intended Use Plan (IUP), which includes the SFY 2020 Water Pollution Control Project Priority List (PPL), is complete and adopted. The IUP details how the program intends to utilize the CWSRF fund and the Project Priority List contains a list of municipalities and private entities that have submitted applications for potential funding in the upcoming year. The final IUP and PPL will be released June 14, 2019. The IUP contains novel funding mechanisms including the Water Infrastructure Sponsorship Program (see below) and an opportunity for low-cost "Bridge Loans" for land conservation projects with water quality benefits. For more information visit: https://dec.vermont.gov/facilities-engineering/water-financing/cwsrf.

- The **Water Infrastructure Sponsorship Program (WISPr)** is a new funding mechanism for natural resources restoration projects. Under this program, up to 10% of a municipality's clean water loan can be used to implement natural resources restoration. A reduced administrative fee over the life of the loan will cover the total value of the sponsored restoration project. Find out how to access this innovative and entirely new funding source for clean water. For more information visit: https://dec.vermont.gov/facilities-engineering/water-financing/cwsrf/WISPr.

- Thee **Lake Carmi aeration project** is under construction with a go-live date expected June 21st. The Department of Environmental Conservation team, in coordination with both Fish and Wildlife and Forests, Parks, and Recreation, will be working with the contractor to install the project this spring. The Department will soon issue a Request for Proposals to sponsor high-resolution monitoring of the effectiveness of the installation. For updates visit: https://dec.vermont.gov/watershed/cwi/restoring/carmi.

Other Initiatives

- **Five Otter Creek Basin NPDES Direct Discharge permits** have been issued for public comment, consistent with the schedule established by the Phase 1 Lake Champlain TMDL Implementation Plan, and the related Otter Creek Tactical Basin Plan. The facilities are: Poultney, Pawlet, Orwell, Fair Haven, Castleton, and Benson. All are scheduled to come off notice June 18, 2019.

- The **Clean Water Lecture Series**, hosted by DEC, highlights Vermont's work to protect and restore clean water. The final lecture for the spring is:
    - **Thursday, June 13 | Lake Score Cards Highlight Restoration Progress and Protection Needs**
      Join Leslie Matthews, an Environmental Scientist with the Lakes and Ponds Program, to learn about the Lake Score Card, a user-friendly interface developed by the program to help Vermonters understand overall lake health. Using Google Earth, viewers can select from more than 800 lakes in the state to learn about four key aspects of lake health: nutrients, aquatic invasive species, shoreland and lake habitat, and mercury pollution. Results from the Lake Score Card have prompted more detailed analyses of statewide trends that reveal progress for some lakes, but also concerning trends in our lowest nutrient lakes. This lecture will be in the Winooski Room (M240) at the National Life Building in Montpelier from 11:00 am – 12:00 pm.

To attend in person, RSVP by emailing anr.cleanwatervt@vermont.gov. Links to past lectures are online at: https://dec.vermont.gov/watershed/cwi/outreach/lecture-series.

Ministère
de l'Environnement
et de la Lutte contre
les changements
climatiques
Québec

Lake Champlain Steering Committee meeting
Jurisdictional reports for Quebec
June 6th 2019, Essex, VT

- In order to prevent illegal dumping of contaminated soils, Québec's government wants **to require the use of traceability for all movements of contaminated soil excavated in Québec**, from the excavation site to the reception site. This new obligation will make it possible to better understand the movements of contaminated soils and, where appropriate, to identify those at fault and to apply the penalties provided for.

- The Ministry of Municipal Affairs and Housing and the Department of Public Safety announce nearly **$ 14 million in financial support to increase municipal resilience to the effects of climate change and help municipal organizations seize opportunities that may arise**.

  - **Climate portraits and fact sheets describing the effects of climate disturbances and associated development opportunities will be developed for each region of Quebec by Ouranos**. These tools will also present examples of adaptation measures that can be put in place by municipal organizations.

- The Quebec government announces **the creation of a ministerial action group to respond more effectively to the needs of people affected by the floods** in recent weeks and also **to prepare Quebec for next year's spring freshet in critical areas**, such as shoreline erosion and flooding.

  - This action group will be mandated to ensure the prompt care and compensation of those affected. It will also be responsible for supporting the municipalities so that they have all the resources they need to recover. The group will also have to help municipalities identify certain issues more quickly to facilitate decision-making. In the medium term, it will also be responsible for **preparing the government and other stakeholders to cope with the floods that could occur in 2020**.

Lake Champlain Steering Committee Updates
US EPA Region 1
June 6, 2019

Regional Realignment Now Complete
EPA has completed its realignment efforts across its Regional headquarters. In Region 1, geographic programs (such as the Lake Champlain Program) and the Surface Water Branch were formerly housed in the Office of Ecosystem Protection. All water programs, including those in the Surface Water Branch (Watersheds and Nonpoint Source, Water Quality and Standards, Wetlands, and Ocean and Coastal), are now under the Water Division.

Grants Timing
Recipients are highly encouraged to begin working with their Project Officers on workplan and budget development to ensure a timely disbursement of funding. The earlier they can begin working together, the earlier the funding package can be finalized and avoid the time crunch (and blood pressure spikes) that often come in September as the end of the fiscal year approaches.

EPA Continues to Monitor TMDL Implementation
As EPA prepares to issue its 2019 Report Card, it continues to monitor progress towards achieving the 2016 TMDL and the remaining Phase 1 milestones. These milestones include the new MS4 permit, the Developed Lands General Permit, and a long-term revenue source as identified in the TMDL accountability framework.

U.S. Fish and Wildlife Service
Updates for Lake Champlain Basin Program Steering Committee
June 6, 2019, Essex, Vermont

The Lake Champlain Fish and Wildlife Management Cooperative: (U.S. Fish and Wildlife Service, Vermont Fish and Wildlife Service, New York State DEC and partners) continue to make progress revising the Strategic Plan for Lake Champlain Fisheries this year with goal of a final draft plan in August, 2019.

A draft Environmental Assessment has been prepared and will soon be released which explains the intent of the Lake Champlain Fish and Wildlife Management Cooperative to add Hoisington Brook and its delta, a tributary to Lake Champlain located in the village of Westport, New York to the existing, federally-authorized, and state- permitted Lake Champlain Sea Lamprey Control Program.

Sea Lamprey control: Results of a TFM lampricide toxicity study were released in April showing no toxicity to mammals at the levels tested resulting in the Vermont Department of Health changing human health advisory thresholds for TFM in Vermont tributaries from 3 ppb to 100 ppb.

Riparian/Wetland Restoration/Aquatic Connectivity: The 2019 field season is off to a great start for the Lake Champlain Fish and Wildlife Conservation Office/Partners for Fish and Wildlife Program.

- In April/May Partners Program staff worked with private landowners, local watershed groups, State and Federal partners, and a host of other conservation organizations to plant over 8,000 native trees and shrubs in watersheds throughout Vermont.
- On May 13, the Lake Champlain Office participated with LCBP and other conservation partners to form the New York Lake Champlain Dam Task Force. The newly formed group hopes to facilitate dam removal in the Lake Champlain Watershed of NY.

Hatcheries:
The USFWS is hosting Andy Dittman, Ph.D. from NOAA Fisheries in Seattle, WA during the week of June 17. Dr. Dittman is a world leader in salmon homing and use of hatcheries for restoration of endangered Pacific salmon populations. Dr. Dittman will be working with the Lake Champlain FWCO Salmon Team and our National Fish Hatcheries in Vermont to provide input on restoration efforts for salmon in Lake Champlain including homing experiments at the Dwight D. Eisenhower National Fish Hatchery.

Salmon Restoration:

- The Lake Champlain Fish and Wildlife Conservation Office (FWCO) partnered with Missisquoi National Wildlife Refuge to launch an Agents of Discovery mission. Agents of Discovery is an interactive app that teaches users about fish and wildlife - the mission theme at Missisquoi is centered around the International Year of the Salmon, but it also teaches users about other wildlife and the important ecosystems found at the refuge as they explore the trails. Lake Champlain FWCO will also be launching a similar mission in partnership with the Lake Champlain Maritime Museum in the coming weeks associated with the Lois McClure visit to Burlington in July.
- Lake Champlain FWCO staff will assist in teaching a professional development course about the International Year of the Salmon and Atlantic salmon restoration efforts in Lake Champlain. The

course will be held at the Lake Champlain Maritime Museum on June 14, from 9 a.m. to 12 p.m. and is open to local park staff, educators, and others.

- U.S. Fish and Wildlife Service, in partnership with conservation groups from around the area, is planning to hold an event to celebrate the International Year of the Salmon in Richmond, VT. The event will take place on October 5th, 2019. Partners will include the Lake Champlain Basin Program, LC Chapter of TU, Central VT Chapter of TU, The Lake Champlain Maritime Museum, Green Mountain Power, Burlington Electric/ Winooski One Partnership, The Friends of the Winooski, Winooski River Conservation District, and Vermont Fish and Wildlife Department.
- The Boquet River habitat survey which was initiated in 2018, is underway this spring and summer. The survey will provide baseline data of available salmon habitat and identify problem areas (e.g. stream bank erosion). This survey will help inform restoration work with partners including The Nature Conservancy and The Town of Willsboro funded in part by the Lake Champlain Basin Program.

Missisquoi National Wildlife Refuge:

- Refuge staff met with Ducks Unlimited, Vermont Department of Fish and Wildlife and the Vermont Land Trust to discuss opportunities for wetland restoration and protection through Ducks Unlimited mitigation program.
- The Swanton Arts Council held a writing workshop at the refuge to develop a script for a film highlighting the International Year of the Salmon and the Missisquoi NWR. This was funded through a grant from the Lake Champlain Basin Program.
- The refuge closed on an easement exchange in combination with the Vermont Land Trust. This project, taking three years, exchanged a USFWS easement on a local farmer's property which was in violation with another easement on the same property - expanding the acreage of lands protected by USFWS easement as well as consolidating all USFWS easements into one block on this property. The Vermont Land Trust was able to place an easement on the agricultural land thereby protecting the remainder of the property, ensuring water quality protection. This allowed the land owner to pay off his mortgage and ensure the land would be protected in perpetuity.
- The refuge held our annual "green up day" with 12 volunteers from Keurig Green Mountain, Global Foundaries and refuge volunteers. We filled a 15 yard dumpster in three hours picking up trash along Rt. 78. Since then refuge staff and volunteers have filled another 15 yard dumpster during normal refuge duties - flooding has delivered more than the normal load of trash to the refuge this year.
- A seasonal Park Ranger started in May who will be focusing on outreach and educational programming.
- Flood waters remain high on the refuge making some field work difficult and boundary posting impossible.
- Great blue herons established a two new rookeries in big marsh slough in May. Since then one has been abandoned.
- One bald eagle nest was lost when the tree blew over on the delta mouth. Two other nests remain stable with at least two young per nest.
- Black terns have started nesting - nests appear to be a bit scattered this year due to high water making nesting habitat in traditional locations sparse.

USACE Update - Lake Champlain Steering Committee

June 6, 2019

WRDA Section 542 Program –
We held a Workshop on March 20th, we plan to hold another this summer/fall for additional proposals to come in. The GMP has been updated (to be sent to LCBP for review by next week) to include the delegation of review/approval for new projects to the regional North Atlantic Division (NAD) office. Once LCBP has input, will discuss the changes at the next Steering or Executive Committee prior to submitting to NAD for review and approval.

Active Projects -
Champlain Canal Barrier Study - An alternative analysis report was received on 22 March 2019 from HDR A/E firm. After reviewing the report, sponsor requested that another alternative (chemical in-lock treatment) should be considered. District is to modify the contract with HDR to include additional work. A charrette/workshop with the stakeholders will be scheduled after alternative analyses is completed, possibly in late summer timeframe.

Jewett and Stevens Brook, St. Albans Bay Wetland Restoration and Phosphorous Reduction Study Phase II - Funds transfer ongoing to kick off project. Maya Dehner will be the Planner and has experience with phosphorus reduction.

Potential Projects -
Moon Brook, Rutland VT - City of Rutland submitted letter for assistance under 542, site visit scheduled for 17 June. Project Summary will be developed following the site visit.

Quagga Mussel Risk Assessment - Project Summary is under development and will be forwarded to LCBP in early June for review and forward to the Technical Advisory Committee.

New York NRCS Lake Champlain Watershed Basin Program
Steering Committee Report
June 3, 2019

Within the Lake Champlain watershed, NY NRCS has offered the following programs:
Regional Conservation Partnership Program-Environmental Quality Incentives Program (RCPP-EQIP) – 2015 Lake Champlain, RCPP-EQIP – 2015 Greater Adirondack, Agricultural Management Assistance (AMA), and EQIP General. At this time the Lake Champlain funding has been fully obligated to contracts and we are working on implementation. The Greater Adirondack is still holding signups to finish obligating funds and is working to implement the obligated contracts. NY NRCS is currently conducting a signup for Edge of Field Monitoring (application cutoff of July 15) as well as two ongoing monitoring contracts. EQIP General has routine signups with contracts obligating annually.

Québec Citizens Advisory Committee
June 2019 Highlights

- Students hired
  - 2 Boat Launch Stewards
    - Venise-en-Québec boat launch
    - Travelling steward – visit smaller lakes scattered throughout Missisquoi Bay basin
  - 1 Education and Outreach agent for new rainwater regulation in Bedford
    - Inform citizens of new duties and inspect location for further action by municipality

- APPLIED for provincial ecosystems improvement project in agriculture-intensive watersheds
  - MELCC partnering with MAPAQ and MFFP
  - Multi-year / multi $M project providing technical, scientific and financial support
  - Work in the field, at the field / stream interface and streambank mobility
  - Work on socio-economic factors influencing decisions
  - Submitted 2 ideal candidate watersheds ready to work
    - Castor brook watershed – 14.6 ha – 28 farms
    - Walbridge brook watershed – 32.4 ha – 44 farms
  - UPDATE : Only 3 candidates left, including BOTH our submissions
  - Meeting with selection committee on June 13 - Decision will be in July

- Continuing work on IJC Missisquoi Bay water quality mandate
  - Final report in French under review – Integration with LCBP / NEIWPCC report
  - Advisory Committee finalizing recommendations
  - Exercise to merge recommendations where possible – June 13 in Grand Isle

- OBVBM AGM will be June 20th in Notre-Dame-de-Stanbridge
  - Will include a special presentation on the benefits of agro-forestry in intensive agriculture

TAC Updates, Lake Champlain Steering Committee meeting

June 6, 2019

The TAC has met twice times since the April Steering Committee meeting.

Reviews and recommendations

- Final report and workplan review: Lake Champlain long-term monitoring program (Approved)
- Final report review: 2018 Cyanobacteria monitoring (Approved)
- Final report and workplan review: Water Chestnut management program (Approved)
- Set FY20 technical program priority recommendations for LC Steering Committee (For Steering Committee review today)
- Final report review: Grassed waterway edge of field study (Approval TBD)
- Review: International Joint Commission water quality recommendations

Updates and presentations

- Presentation: Atlantic salmon restoration in Lake Champlain
- Presentation: Overview of Education and Outreach and Champlain Valley National Heritage Area programs
- Update: McKenzie Brook flow and water quality study

E&O Committee Report to the Steering Committee
June 6, 2019

The E&O Committee met on May 10th to review the budget results.

COOL GRAPHICS CREATED

Staff designed the *International Year of the Salmon passport for CVNHP*, and several fliers for events including the Scoping Out Lake Champlain's Food Web/Cyanobacteria Monitoring Training event at Valcour Boathouse on June 11th.

RESOURCE ROOM

New exhibits in the Resource Room include Nature Based Solution - green infrastructure. Staff created a Basin Rocks and Fossils exhibit to complement ECHO's dinosaur exhibit which just finished. Currently staff and our new outreach stewards are creating Break the Habit: Swap Out the Plastic exhibit. Staff has been gleefully swamped with many NY and Vermont school groups.

WATERSHED FOR EVERY CLASSROOM

Six educators completed the 10 month - 6 credit Watershed for Every Classroom course on May 3-4th. These teachers shared highlights of their classroom/outdoor experiences this year. Collectively they taught 414 students, but over a three year period, this number will be closer to 1200 students. One of the coolest outcomes was that the Burlington earth science teachers created a new 10 day optional unit for students who wish to focus on green infrastructure. Some of the CBEI partners will assist.

HEALTHY SOILS INITIATIVE-RAISE THE BLADE

Work continues on this campaign with marketing ads running for two months on 5 Chittenden County buses, ends June 30th.

About 20 commercial businesses, NGOs have joined this campaign. In return, they receive a shout out on the Lawn to Lake website and can distribute brochures featuring their logos with text indicating that they have made the change to their lawn care practices.

More work will continue in Plattsburgh this spring. Residential customers and business in South Burlington, Plattsburgh and now likely St Albans are the target audiences.

YWCA/YMCA SUMMER CAMP WATERSHED EDUCATION PROGRAM

There is interest in completing a 2nd year w/ YMCA Camp Abnaki and YWCA Camp Hochelaga, perhaps with more support from an Education and Outreach Watershed Steward. We have offered support for the counselors this summer and are awaiting results. We have also been contacted by the Swanton Elementary School summer camp for programming assistance.

E&O STEWARDS

Kathleen Lewis and Sue Hagar have been hired as our two outreach stewards this summer. Working with the E&O committee, we gathered suggestions for several events that they might participate in this summer. They are opening some new doors, assisting in the resource room as needed and covering events and student field days.

ECHO STATE OF THE LAKE EXHIBITS

Staff assisted in developing and editing a new exhibit at ECHO to be based the *2018 State of the Lake Report* content. An interactive lake reporter station and interior exhibit panels will be completed in June. Exterior wayside exhibit panels based on SOL content are expected to be completed in July.

TMDL OUTREACH TOOLS

A new contract was awarded to Peregrine Productions for designing TMDL outreach messaging.

***DIVING IN* VIDEO SERIES**

The volunteer Adirondack Backcountry Ponds monitoring video was finalized and released on the LCBP website.

INTERNATIONAL YEAR of the SALMON VIDEOS – In partnership with US Fish and Wildlife Service, three segments focused on salmon restoration were produced. The first Salmon Video will be featured as part of the DIVING IN series. Editing was completed on the narration for all three videos yesterday. The series will be compiled into one segment and aired on VT PBS later this summer (we'll also see if NY is interested), and shared through various media outlets and partners.

Champlain Valley National Heritage Partnership

Lake Champlain Basin Program

Heritage Area Program Advisory Committee

Report to the LCBP Steering Committee

June 6, 2019

FY2019 CVNHP Workplan and Budget

The LCBP Steering Committee approved 17 projects totaling $149,630 at its April 10, 2019, meeting in Québec. Following the decision, the LCBP staff was notified by the National Park Service that the CVNHP's budget will be $332,098 for FY2019—$32,098 more than what was anticipated. These additional funds will pay for two $7,500 projects that fell below the funding threshold considered in April: 1) **Inventory Collections Initiative** project by the **Lake George Historical Association** to expand staff hours to complete a comprehensive inventory/database of LGHA's artifact/archival collections by December 2020; to appraise, conserve and/ or display at least one rare collection item, establish an ongoing intern/volunteer infrastructure for community museum participation; collection protection through a green retrofit/climate control plan; and 2) **Hildene, The Lincoln Family Home** for the **Vermont's African American Heritage Trail** (VAAHT) that will provide revised and updated educational/promotional materials to sites along the VAAHT while initiating outreach to partners at black heritage sites in New York and Québec, as well as increasing access for educators and the public to trail materials and history. The remaining funds will be used to develop two sets of traveling exhibits for the **2020 Centennial of the 19th Amendment**. The panels will interpret the history of the women's suffrage movement in New York, Vermont and Québec.

2019 CVNHP International Summit

The annual **CVNHP International Summit** will be held in Venise-en-Québec on Monday, October 7 with an optional field trip on Sunday, October 6, 2019. The meeting will focus on accomplishments of the last year, preparations for celebrating the 2020 Centennial of the 19th Amendment, and a discussion on the 2021 focus on the 100th anniversary of prohibition.

International Year of the Salmon

Interpretive Displays

The LCBP developed four sets of traveling displays interpreting the natural and cultural heritage of the salmon, their early-19th century extirpation from Lake Champlain, the retrodiction of the fish in 1972, and the challenges facing biologists to keep the species healthy and viable in the lake. The exhibits have been featured at the Love the Lake Speakers Series, the Vermont State House, the Annual NEIWPCC All-Staff Meeting, the Lake Champlain Fish and Wildlife

Management Cooperative meeting, Paul Smith's College, the Lake Between Conference, Missisquoi National Wildlife Refuge, Kamp Kill Kare State Park, and the Ticonderoga Historical Society Museum. A set of exhibits is on display at Chimney Point State Historic Site for the summer season. The Lake Champlain Maritime Museum will feature the exhibits in June and they will be a focal point of the summertime tour of the replica canal schooner *Lois McClure*.

CVNHP Salmon Exhibits on Display at Chimney Point State Historic Site

IYS Festival

The LCBP and USFWS staff are collaborating with partners to develop an IYS Festival in Richmond, Vermont, on October 5, 2019. The festivals will include an interpretive canoe paddle on the Winooski River, fly-casting lessons on the Village Green, presentations on the history and recovery efforts of the salmon in Lake Champlain, and the stocking of fingerlings in the Winooski.

2019 Tour of the *Lois McClure*

The replica canal schooner, Lois McClure, will mark the IYS with a tour of Lake Champlain. The vessel will serve as an educational platform to share the interconnected relationship between history, culture and the environment through the story of salmon in our region. Tour dates:

- July 2: Preview Night in Burlington
- July 4-7: Burlington, Open to the public 10am-5pm
- July 13-14: Westport, Open to the public 10am-5pm
- July 13: Westport Marina Saturday Night BBQ
- July 20-21: Plattsburgh, Open to the public 10am-5pm
- July 27-28: Willsboro, Open to the public 10am-5pm
- August: Open for guided tours at Lake Champlain Maritime Museum