Ph.D. Project : summary, highlights and steps forward

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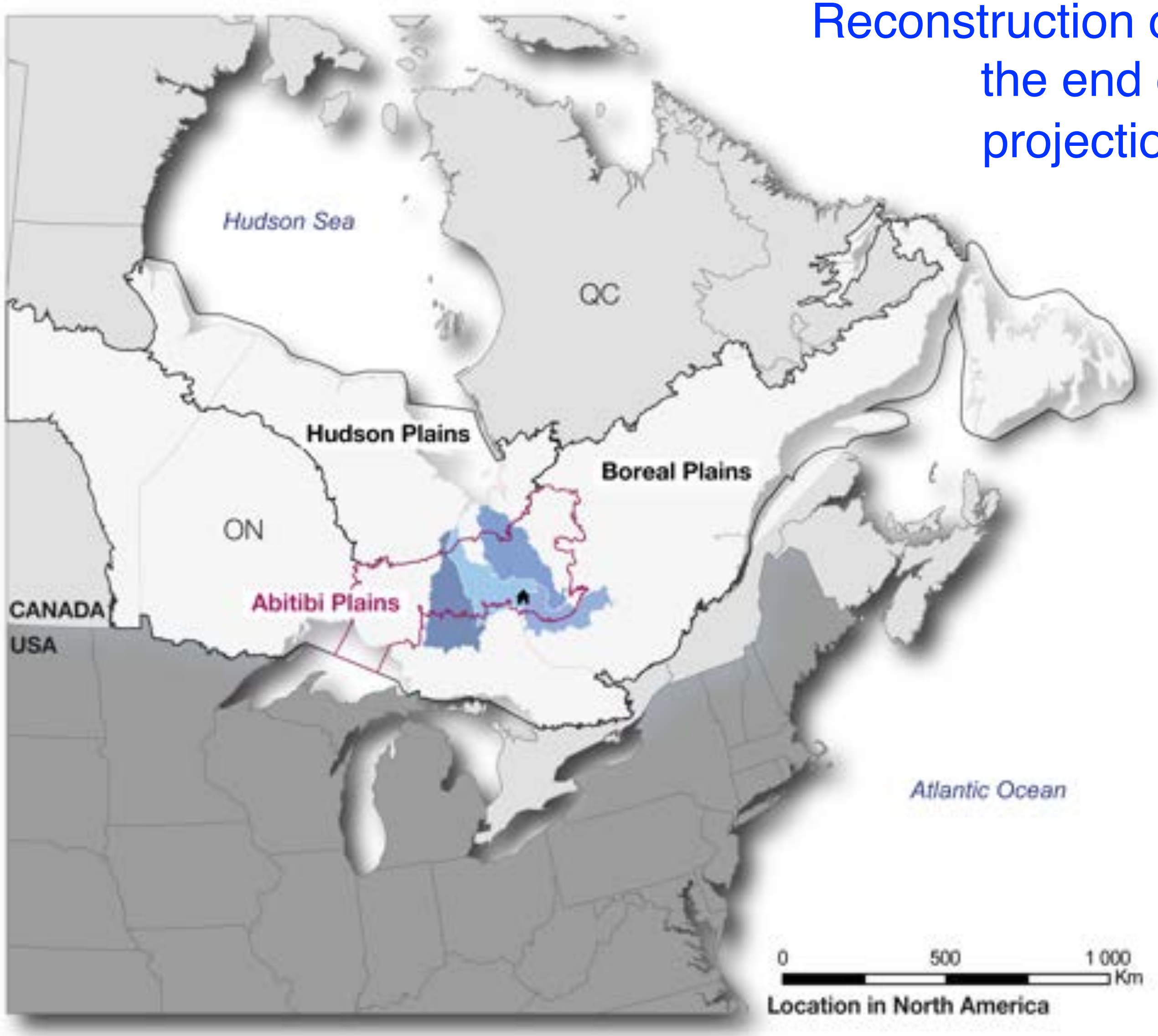
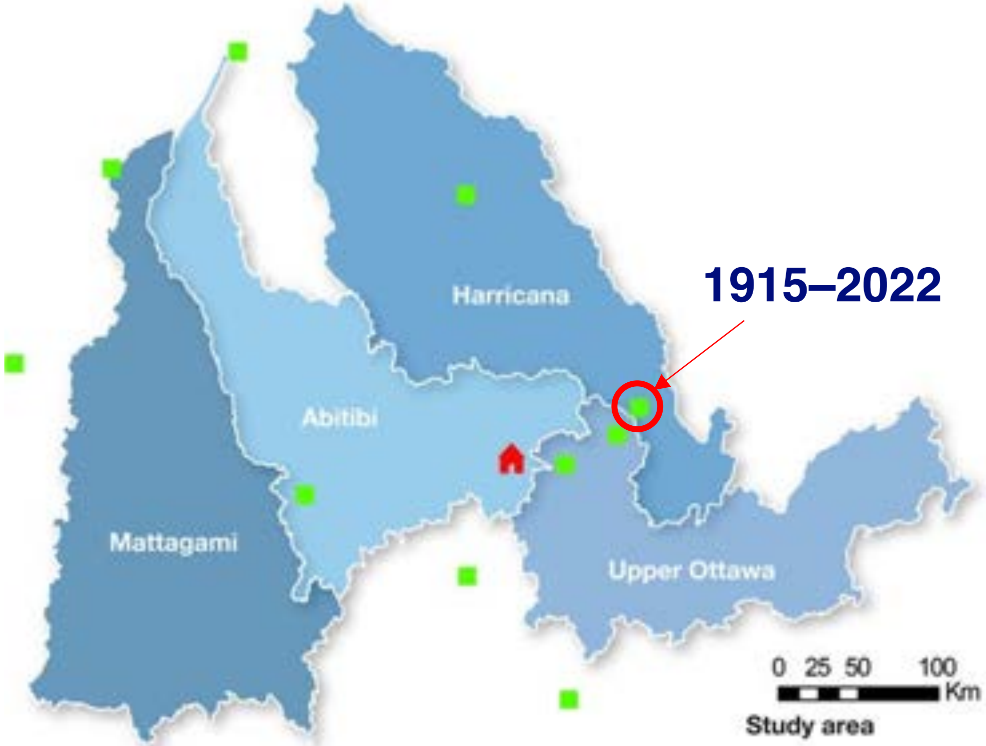
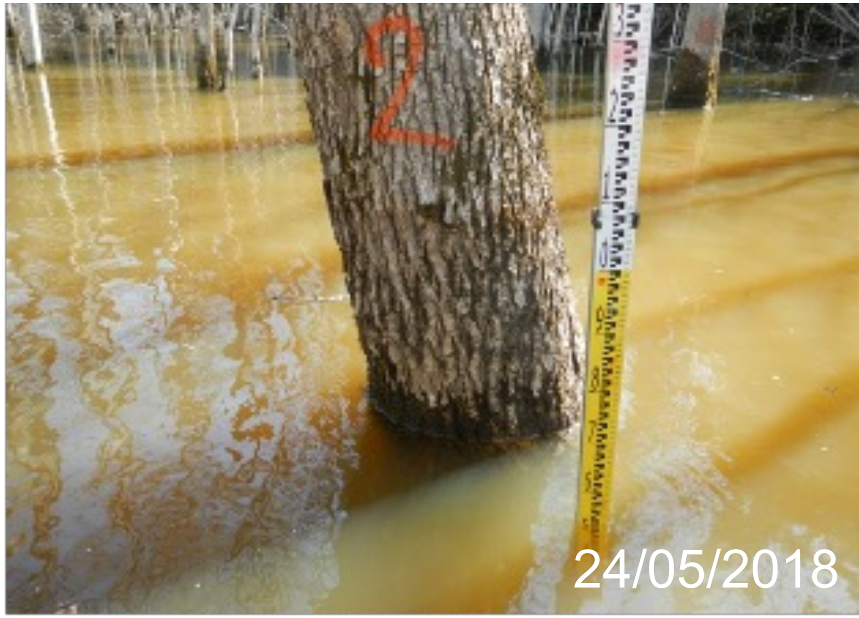
Project aims & Study area

Reconstruction of high spring discharge of the Abitibi Plains since the end of the Little Ice Age (1750 to present) and projections of the potential climate change effects



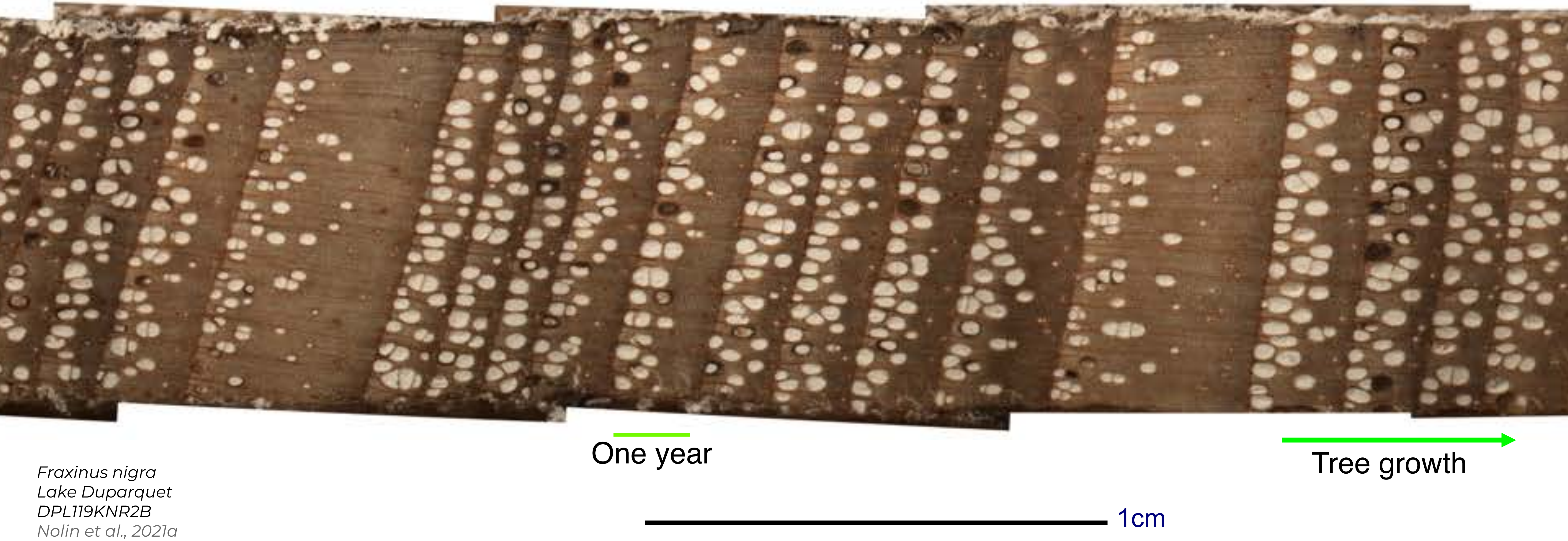


Derive proxies from periodically flooded trees



Flood rings in black ash

FLOOD RING = more numerous and smaller earlywood vessels compared to normal tree rings



Fraxinus nigra
Lake Duparquet
DPL119KNR2B
Nolin et al., 2021a

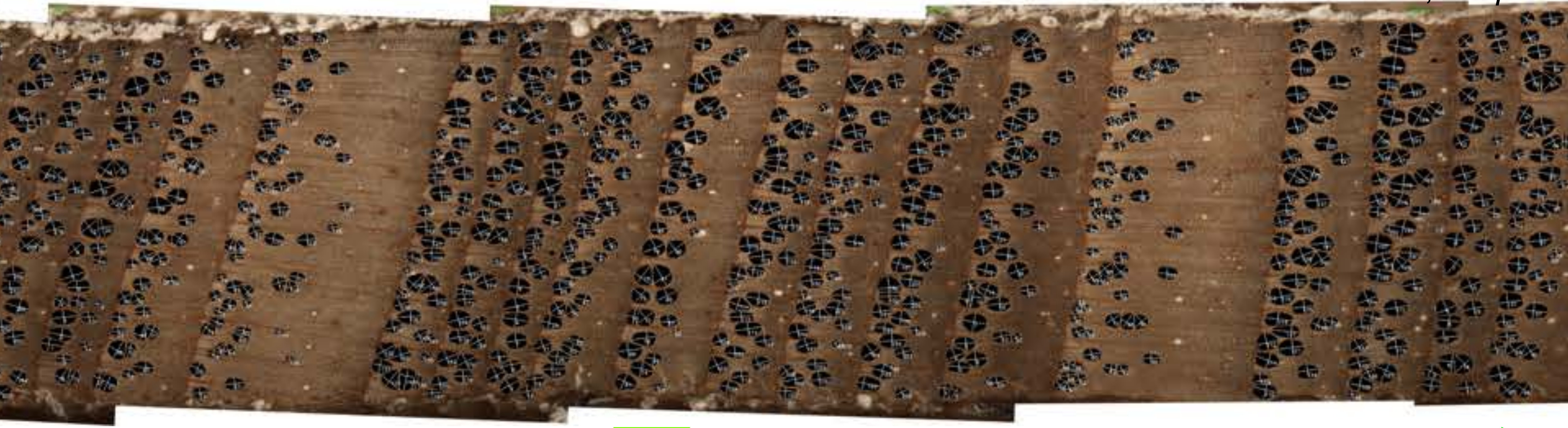
Flood rings in black ash – Quantitative Analyses

FLOOD RING = more numerous and smaller earlywood vessels compared to normal tree rings

1979
Spring Flood

1989
Spring Flood

≥ 3,000 μm



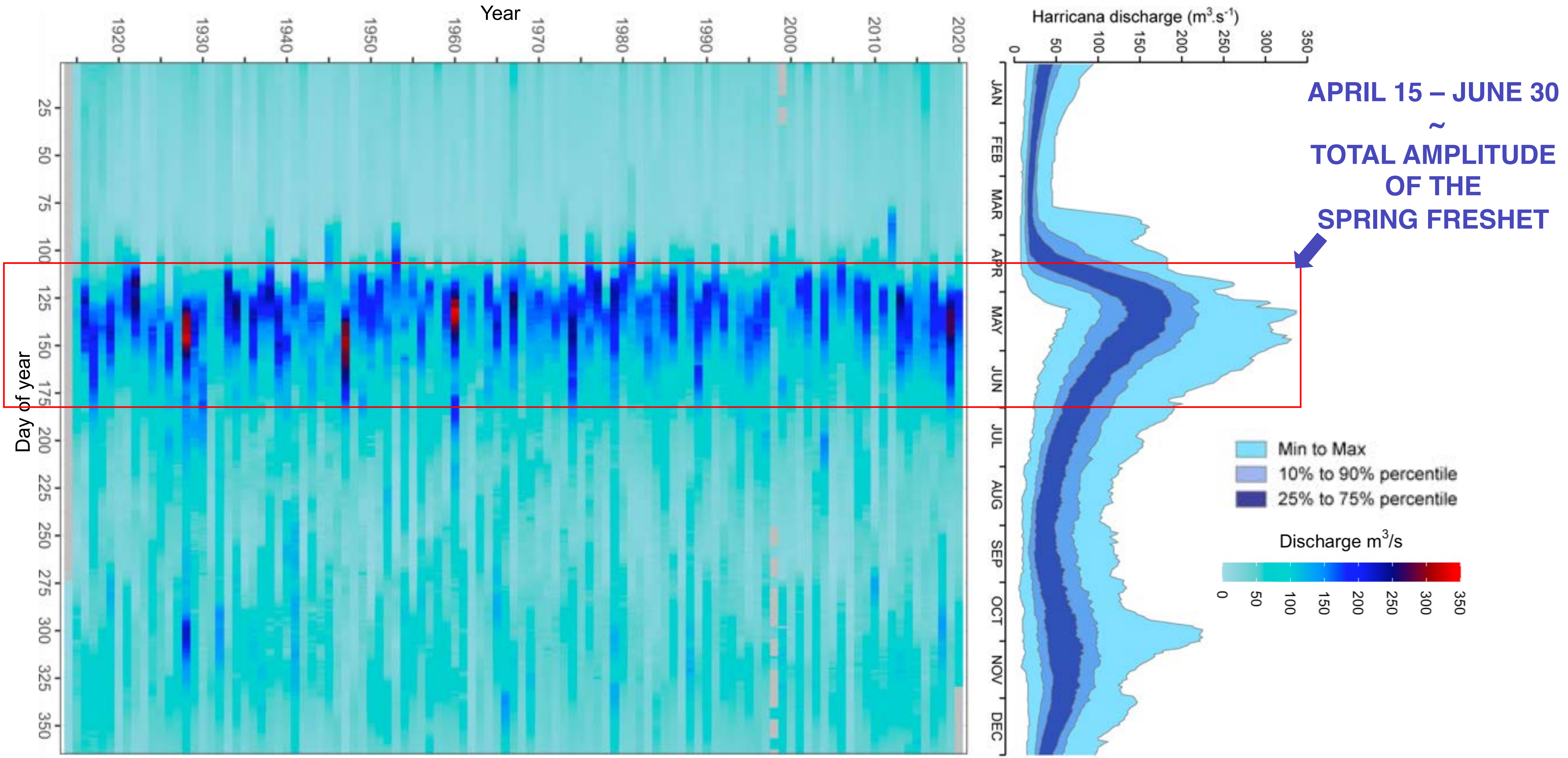
One year

Tree growth

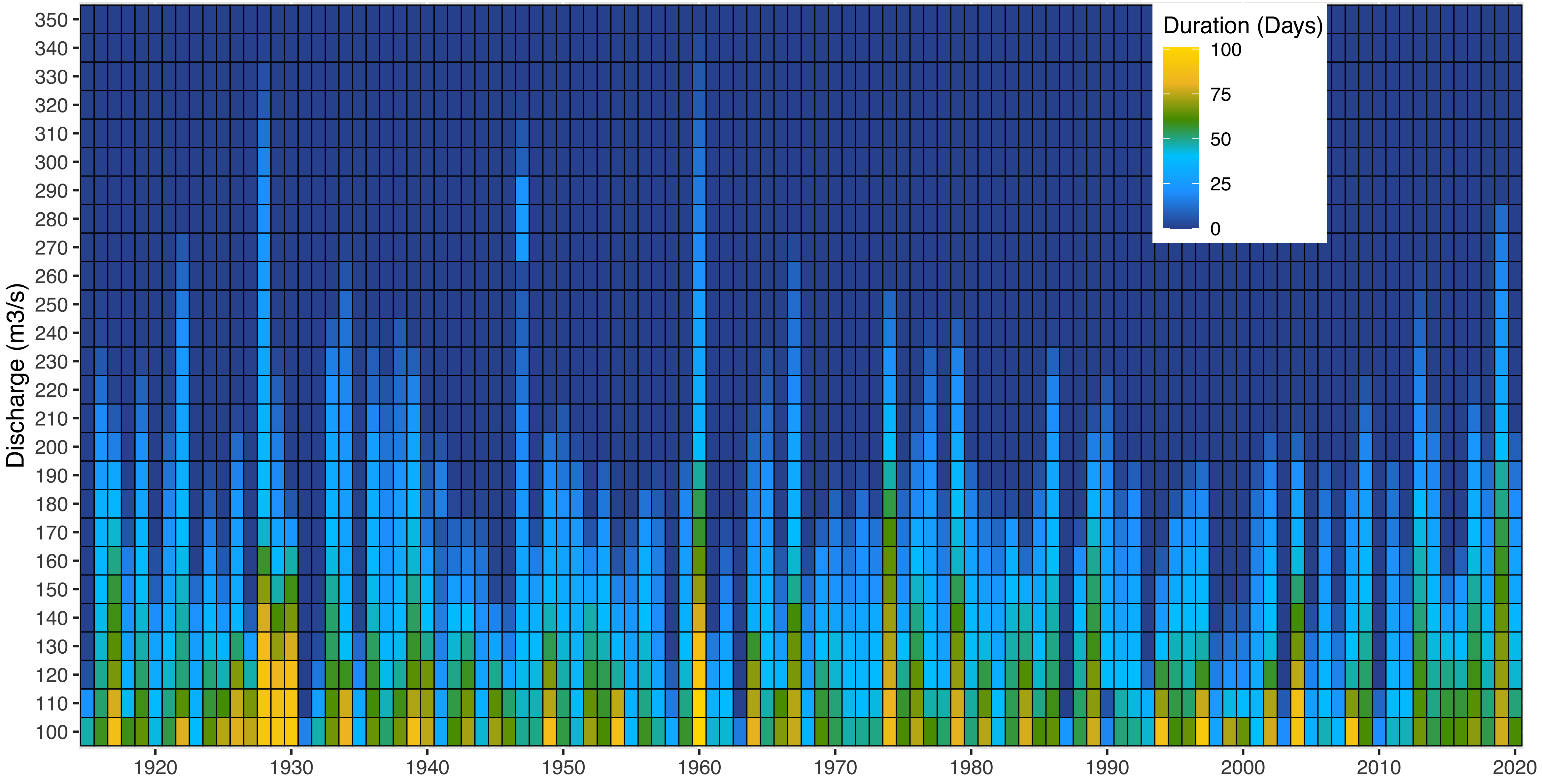
1cm

Fraxinus nigra
Lake Duparquet
DPL119KNR2B
Nolin et al., 2021a

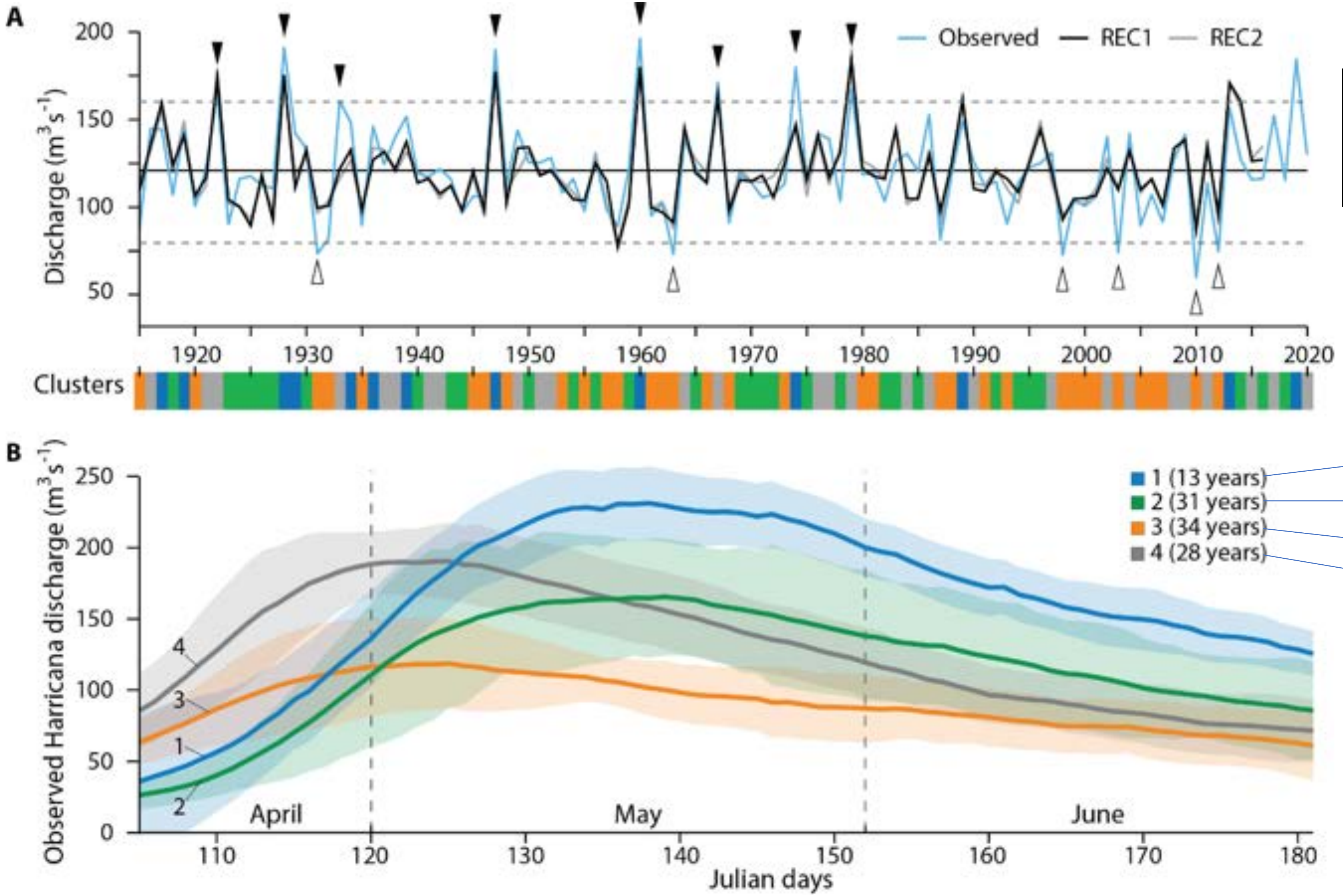
Proxies of the total spring freshet amplitude



How does vessel features track flood behaviors ?



How does vessel features track flood behaviors ?



RECONSTRUCTION
MODEL CALIBRATION

43 trees (62 samples)

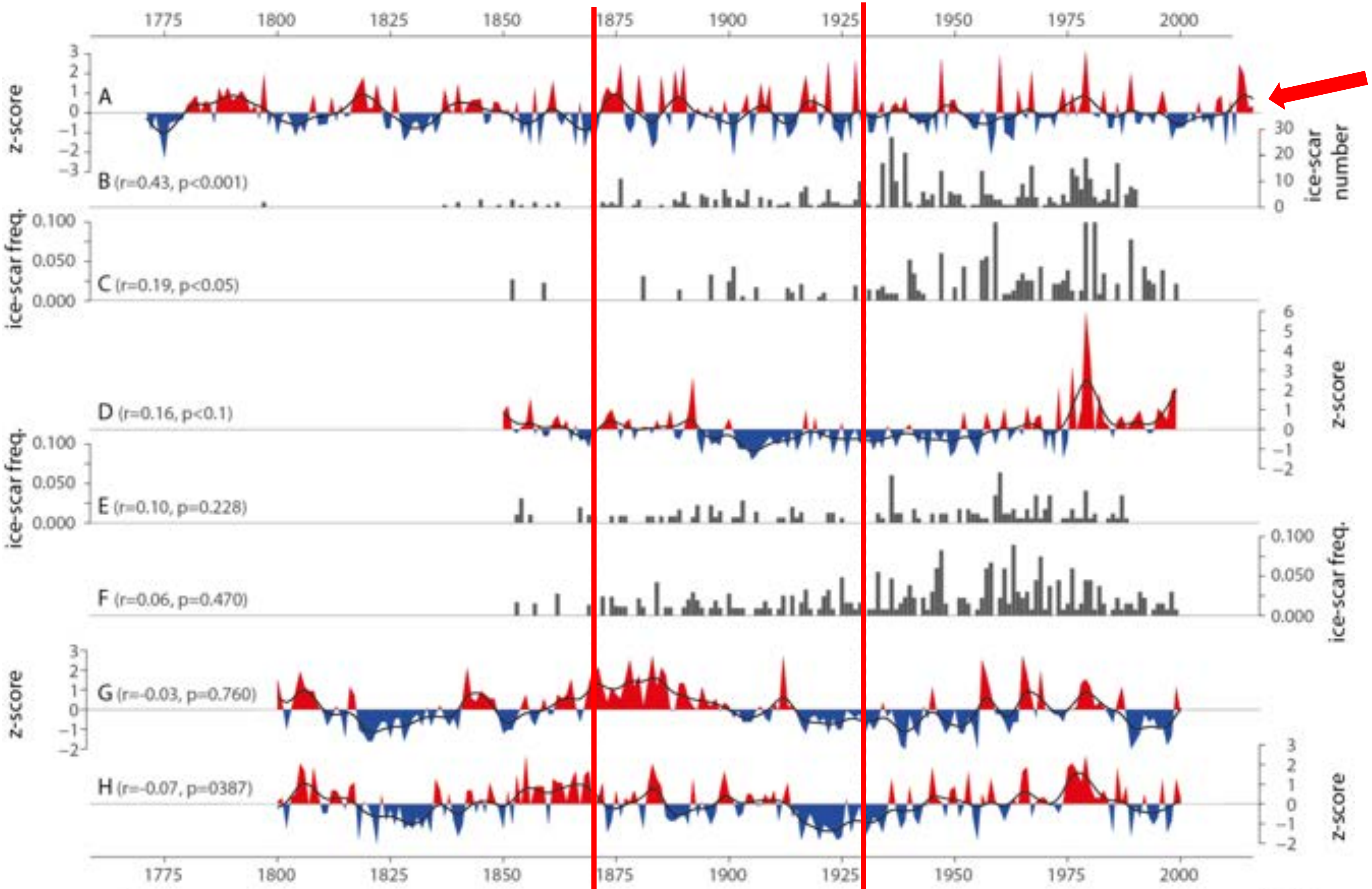
= 5 trees

R^2_{adj} = 68.5%

LATE MAXIMUM
LATE LOW
EARLY MINIMUM
EARLY INTERMEDIATE

K-MEANS CLUSTERS OF
DAILY OBSERVED
DISCHARGES

Regional spring flood variability



HARRICANA SPRING DISCHARGE RECONSTRUCTION

INCREASING MAGNITUDE AND FREQUENCY

1870 I 1930

SAME PERIODS OF CHANGE INDICATED IN PALEO-RECORDS FROM NORTHERN QUEBEC

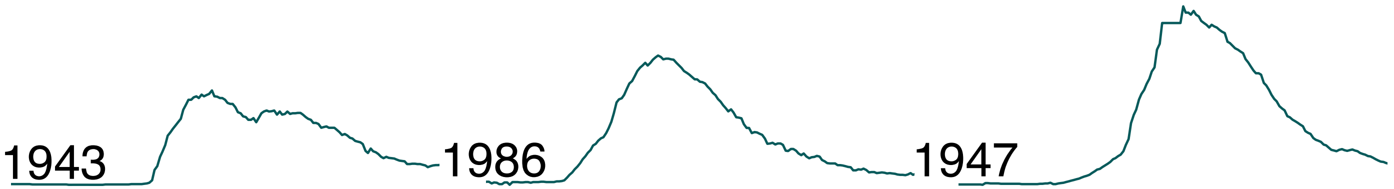
Chronologies from (B) Duparquet - Tardif et al., 1997b; (C) Corvette - Lemay & Bégin, 2008; (D) Caniapiscau (May) Boucher et al., 2011; (E) Bienville – Bégin, 2001; (F) Montausier – Boucher et al., 2011; (G) Caniapiscau (annual) – Nasri et al., 2020; (H) Caniapiscau (spring) – Niault et al., 2014

Flood rings in black ash – Semi-Quantitative Analyses

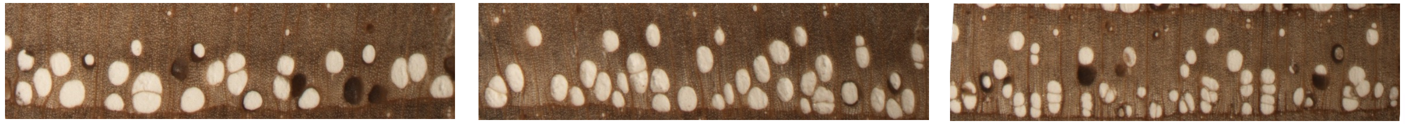
...

0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 1 - 2 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 2 -0 - 0 - 0 - 0 - 0 - 0 - 1 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0

Spring flood magnitude of the Harricana River



Intensity of vessel modifications

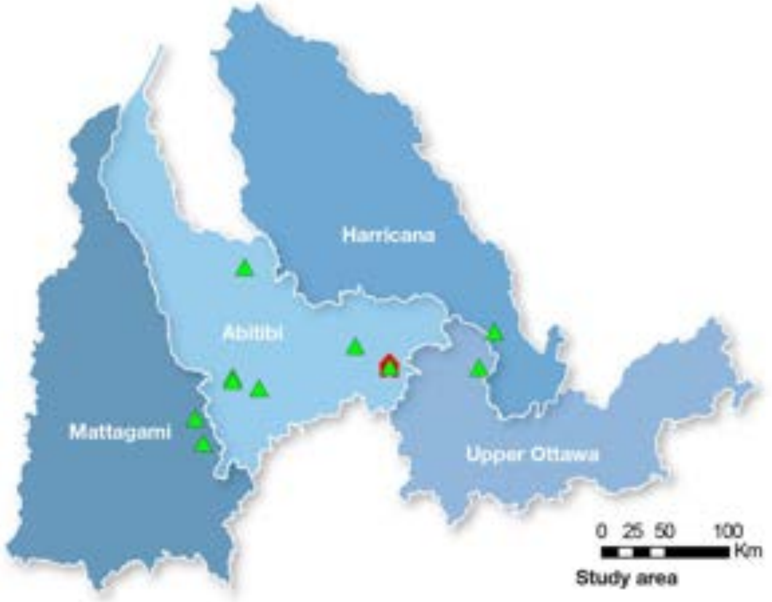


F0
no change

F1
increase in number supported by size decrease

F2
well-defined flood ring

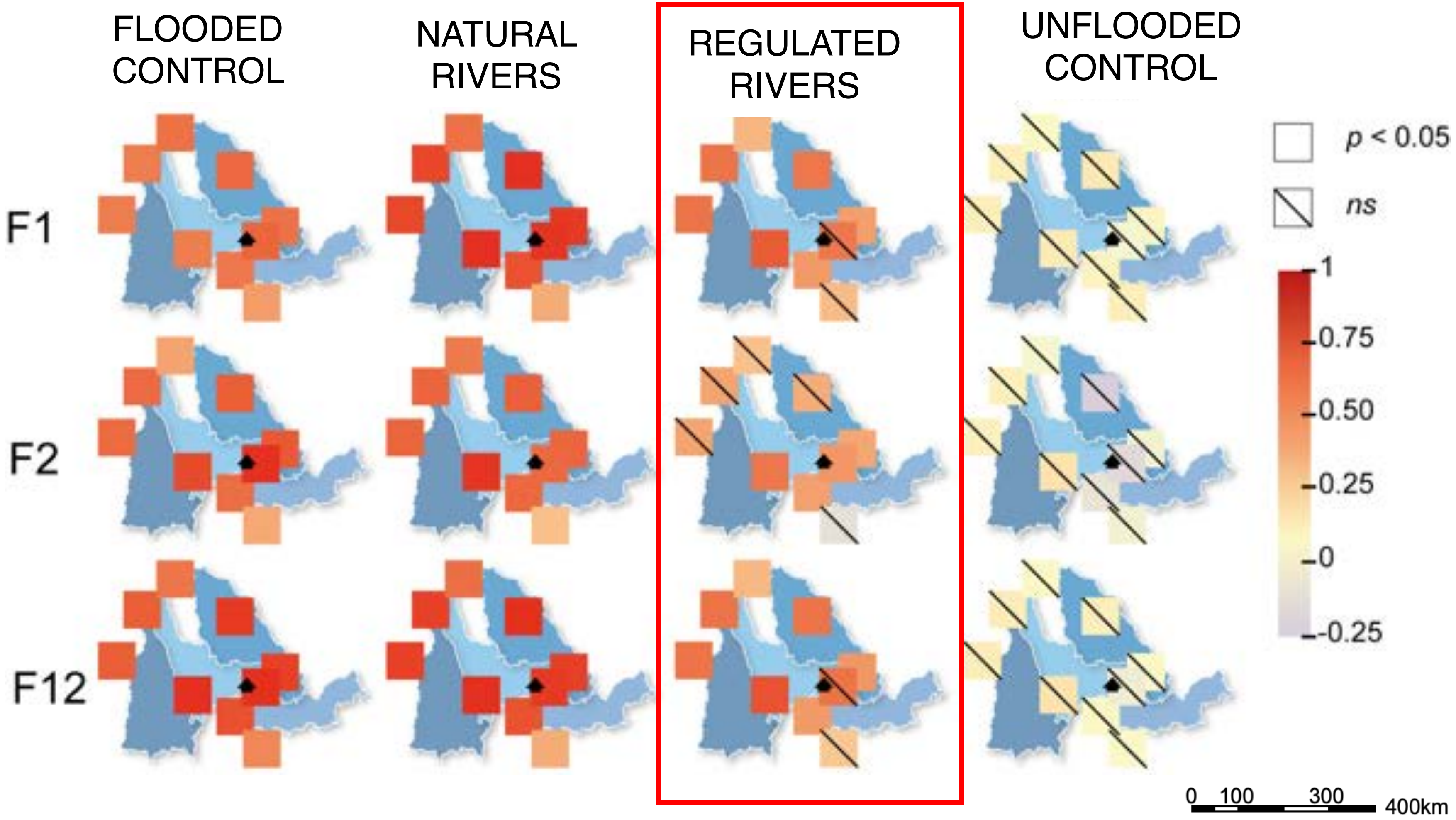
St Georges et al., 2010; Kames et al., 2016



Regional spring flood variability

SPATIAL COHERENCY BETWEEN OBSERVED SPRING DISCHARGE FROM NATURAL RIVERS AND FLOOD RING RELATIVE FREQUENCIES

10 SITES , 993 CHRONOLOGIES FROM 470 TREES (1701-2016)

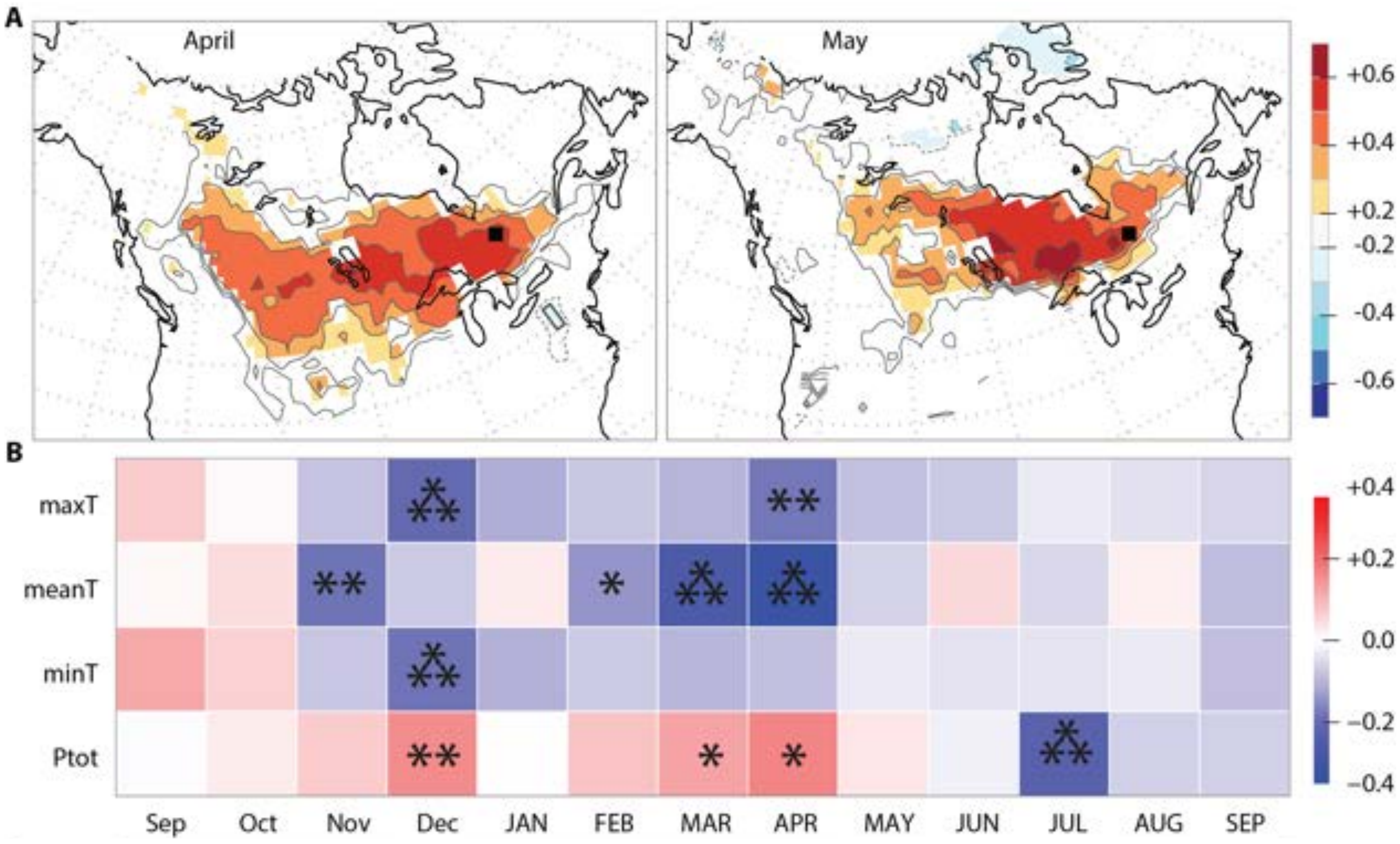


Climate drivers of regional spring floods

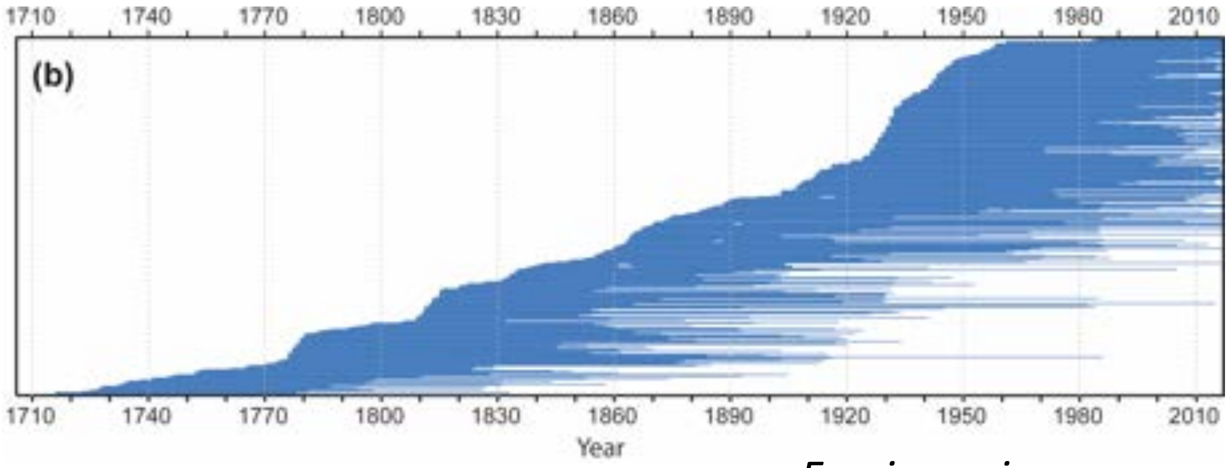
SPRING FLOODING ASSOCIATED TO
SNOWY AND COLD WINTERS & RAINY AND LATE SPRINGS (break-up)
& ACROSS MUCH OF CENTRAL-EASTERN CANADA

SPATIAL CORRELATIONS
NOAA RUTGERS SNOW
COVER EXTENT
1966–2016

BOOTSTRAPPED
COORELATIONS
CRU TS4.03 CLIMATE
1900–2016



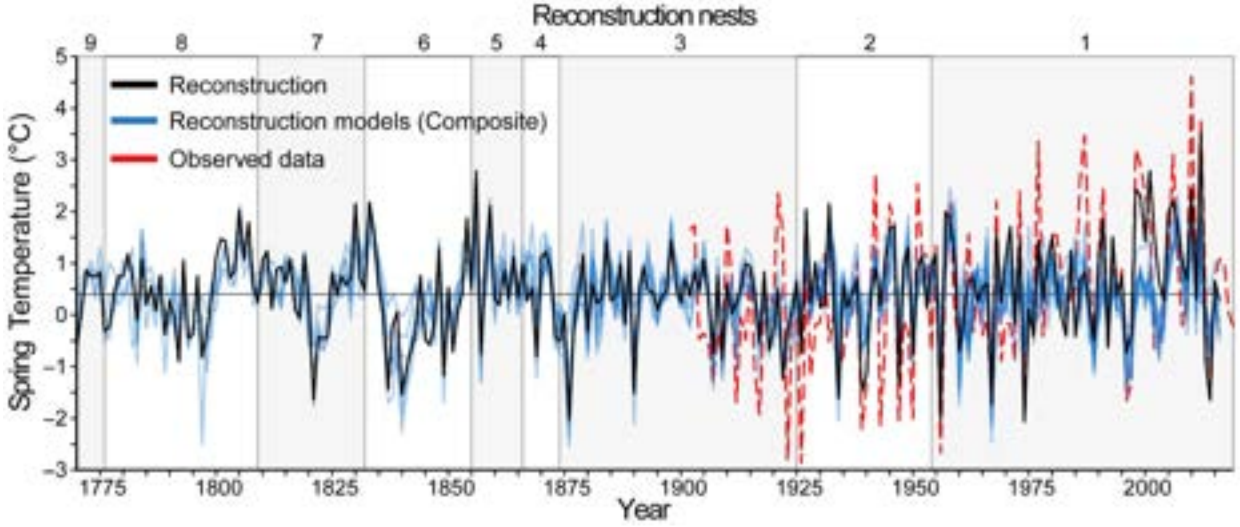
Spring temperature reconstruction



Pinus Banksiana
EW, LW, RW
345 trees (722 samples)

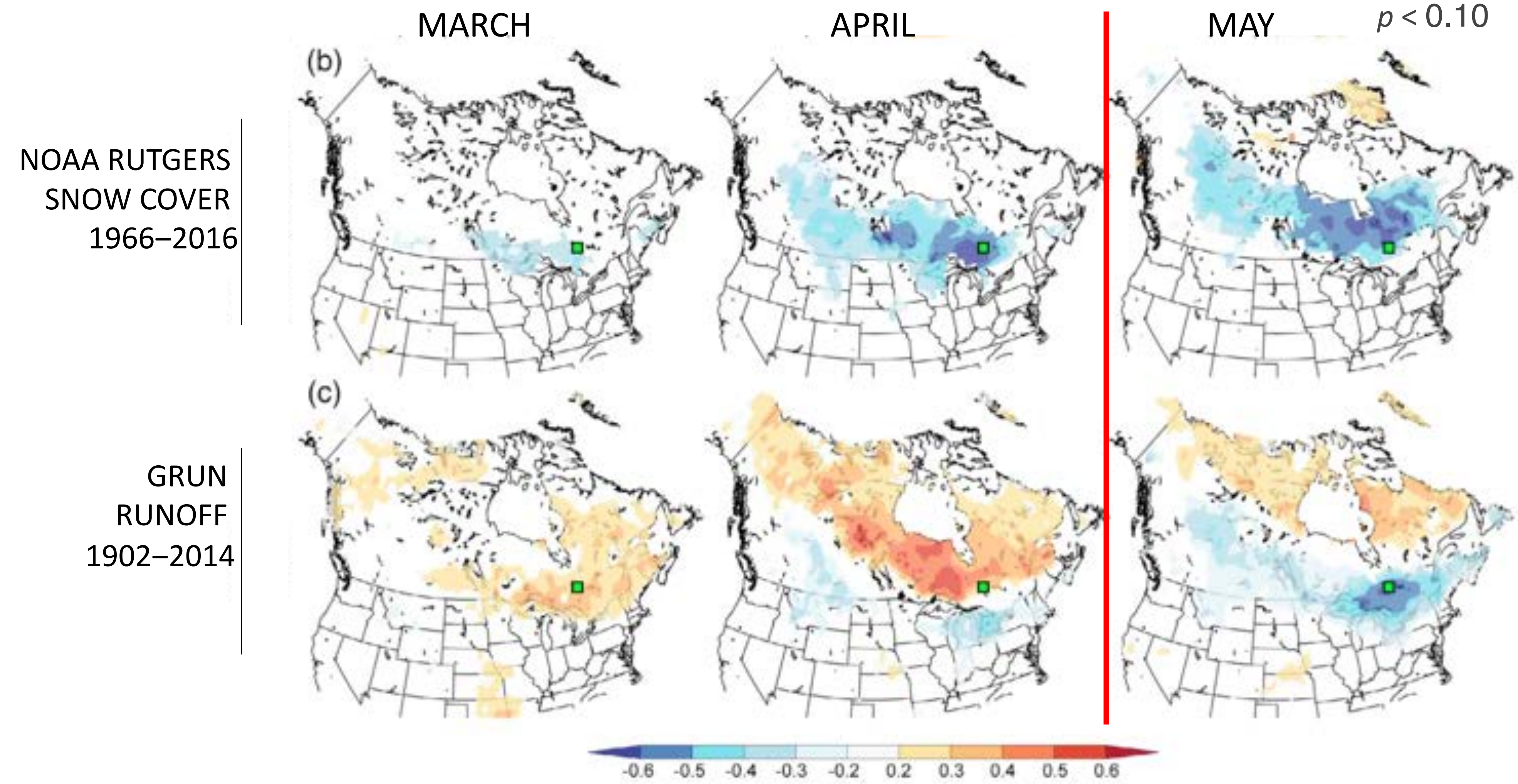
+

Fraxinus nigra
EW VESSELS
(FLOOD RINGS)
43 trees (62 samples)



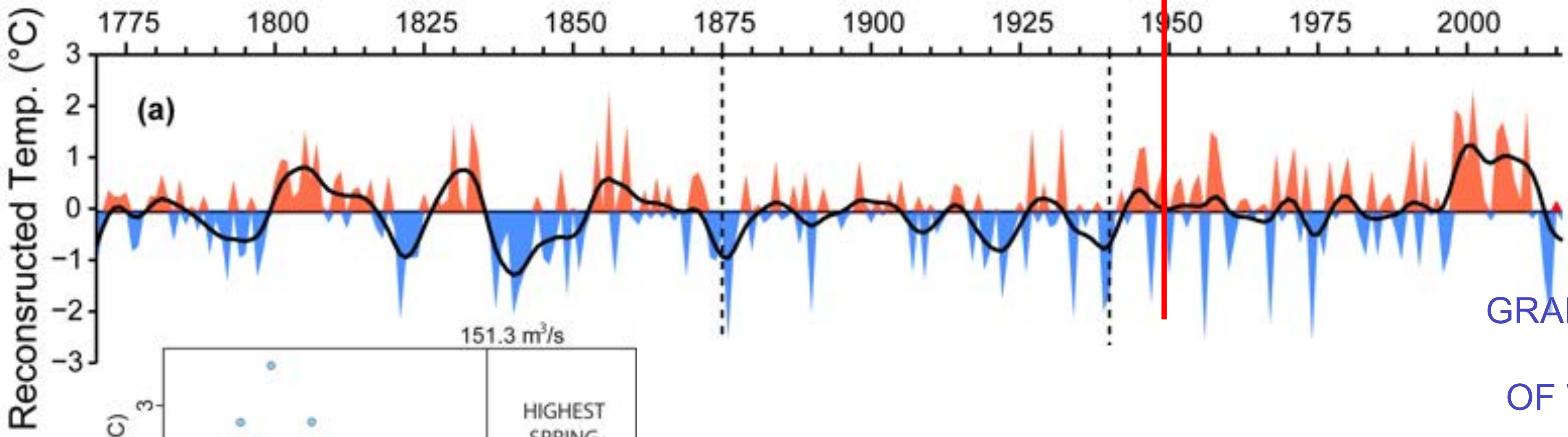
Spring temperature reconstruction

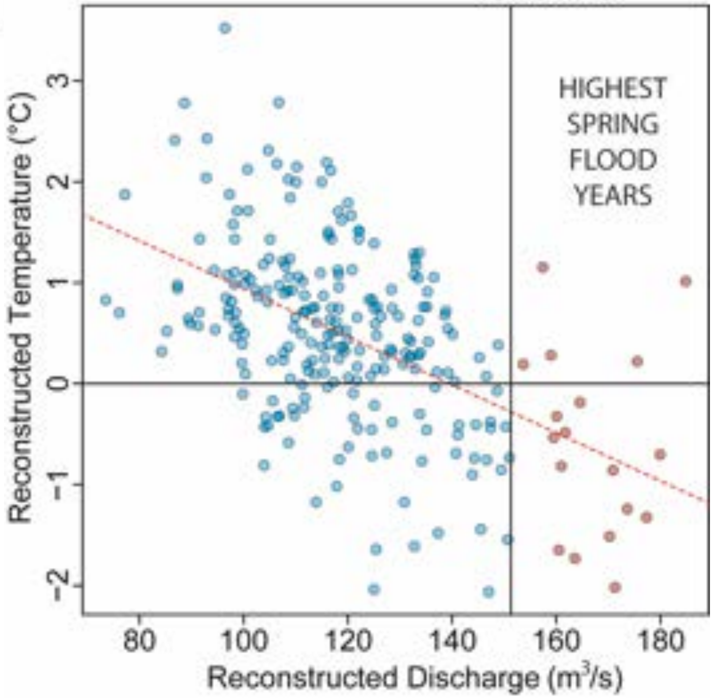
MAR-APR HIGH DISCHARGE WARM & EARLY SPRINGS
MAY HIGH DISCHARGE COLD & LATE SPRINGS WITH LATE ICE BREAK-UP AND PERSISTENT SNOWPACK (+RAIN)



OBSERVED LAKE DUPARQUET ICE BREAK-UP
$r = -0.54$, $p < 0.001$, 1968–2016

RECONSTRUCTED MEAN SPRING AIR TEMPERATURE





GRADUAL CHANGES IN PERIODICITY
OF WARM AND COLD PHASES IN
~1875 & ~1940s

QUICKER CONTRIBUTION OF SNOWMELT IN RUNOFF ?
CHANGE IN CONTRIBUTION OF SNOW vs RAIN IN SPRING FLOODING PROCESSES ?

RECONSTRUCTED HARRICANA RIVER MEAN SPRING DISCHARGE

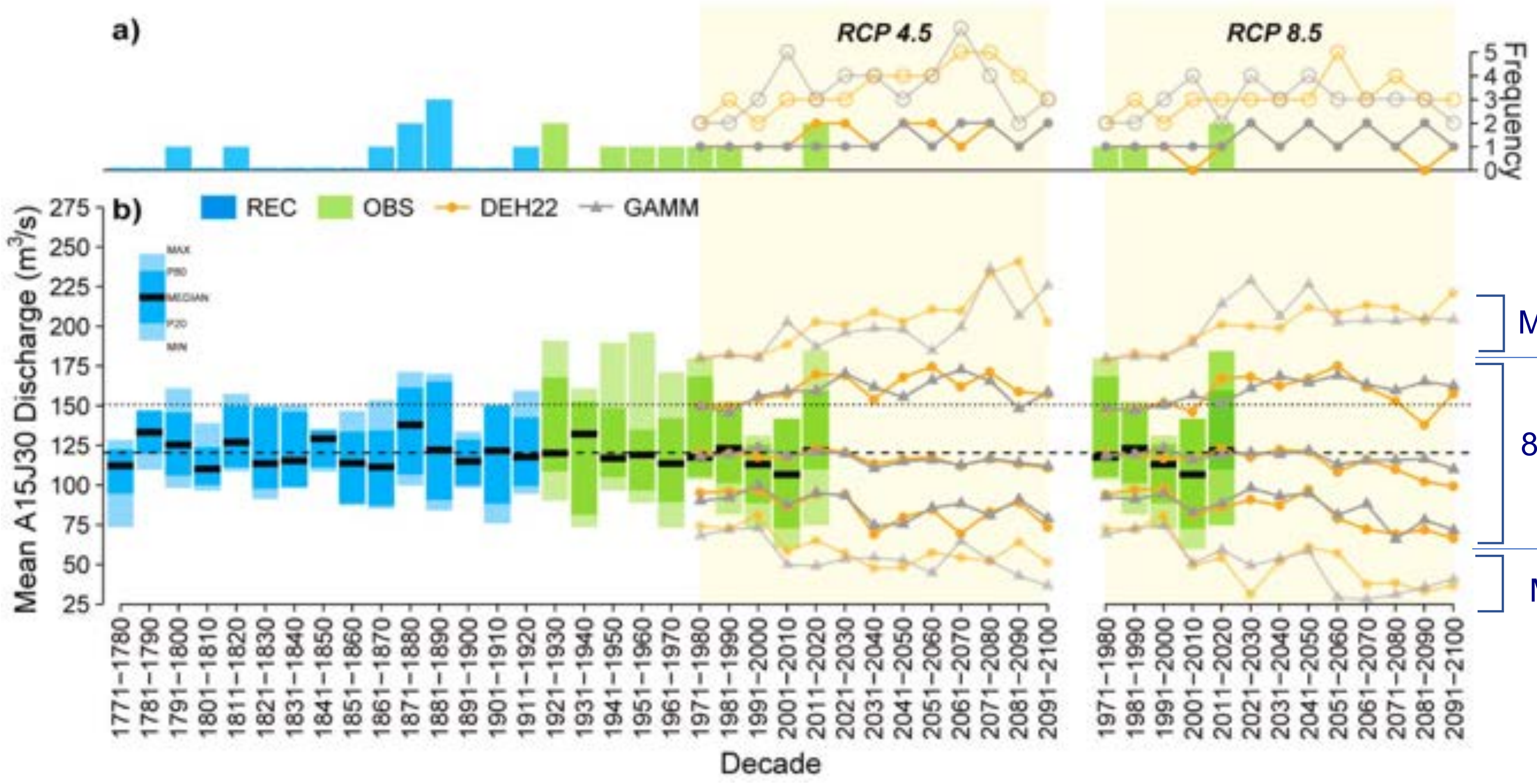
r = –0.52, $p < 0.001$, 1771–2016

Long-term perspective on spring discharge variability

10-YR WINDOWS COMPARISON BETWEEN
RECONSTRUCTED, OBSERVED, AND PROJECTED
MEAN DISCHARGES OF THE UPPER HARRICANA RIVER

Optimistic scenario

Pessimistic scenario

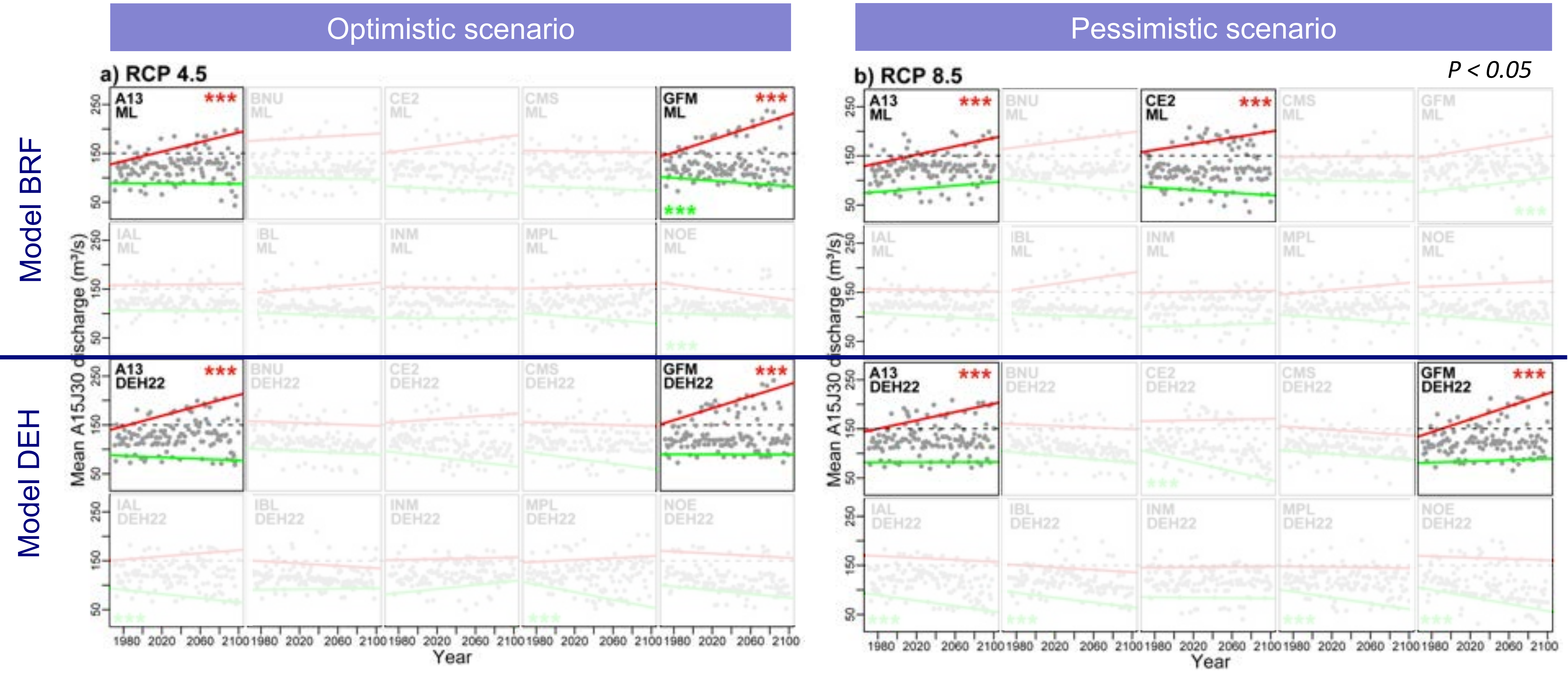


	Change
MAX	INCREASE
80%	SIMILAR TO THE HISTORICAL RANGE OF VARIABILITY
MIN	DECREASE

Long-term perspective on spring discharge variability

0.10 AND 0.90 QUANTILE REGRESSIONS ON THE TWO HYDROLOGICAL MODEL OUTPUTS AND FOR EACH OF THE 10 GCMs

1 BOX = 1 CLIMATE MODEL FROM THE 10-GCM ENSEMBLE



Outcome

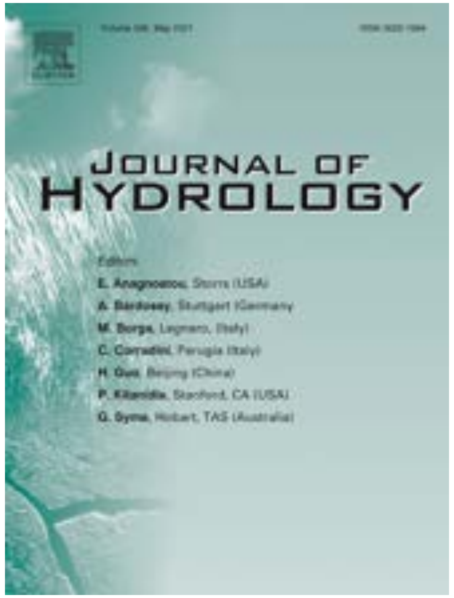
UNIQUE HISTORICAL REGIONAL PERSPECTIVE OF

(1) HIGH SPRING DISCHARGES AND (2) SPRING TEMPERATURES,

PROMISING APPLICATIONS FOR FLOOD RINGS,

A UPDATED BASIS TO UNDERSTAND THE MECHANISMS DRIVING LARGE-SCALE SPRING FLOODING

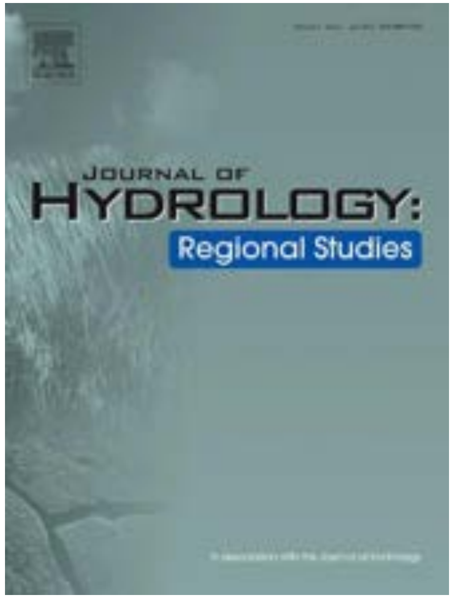
Feb 2021



Feb 2021

Oct 2021

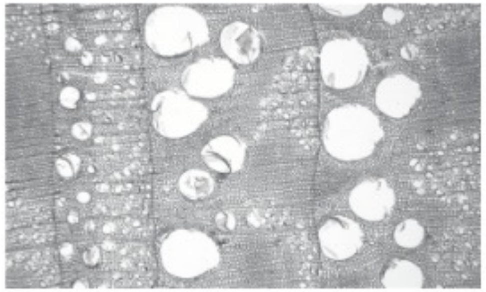
Feb 2022



Jun 2023

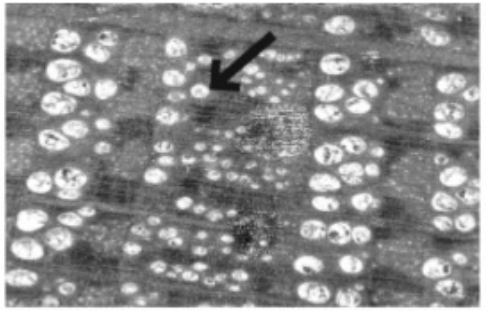
Characterize flood rings in multiple riparian species

RING-POROUS TREE SPECIES



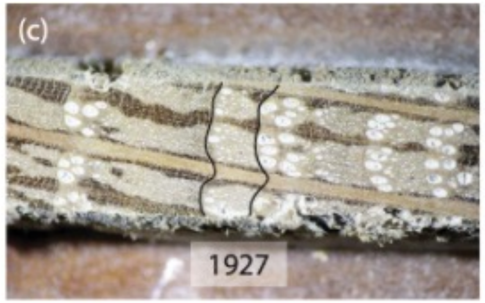
Shrunken earlywood vessels and anomalous latewood with disrupted flame parenchyma and little fiber in *Quercus macrocarpa* from the Red River flood in 1826, Canada.

St George, 2010 – Tree Rings and Natural Hazards



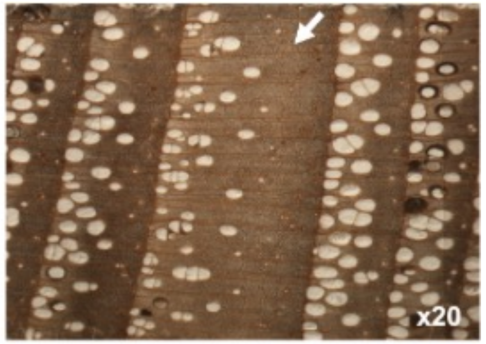
Shrunken and extended earlywood vessels into the latewood in *Quercus macrocarpa* from the Red River flood in unknown year, Canada.

Wertz et al., 2013 – Water Resources Research



Reduced earlywood vessel area and disorganized parenchyma in *Quercus lyrata* from the White River flood in 1927, USA.

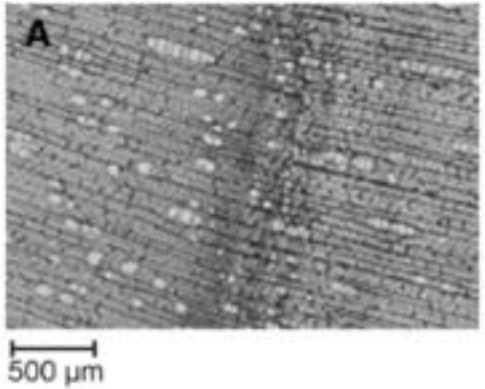
Meko et al., 2019 – Physical Geography



Reduced area and increased number of earlywood vessels in *Fraxinus nigra* from the Lake Duparquet flood in 1989, Canada.

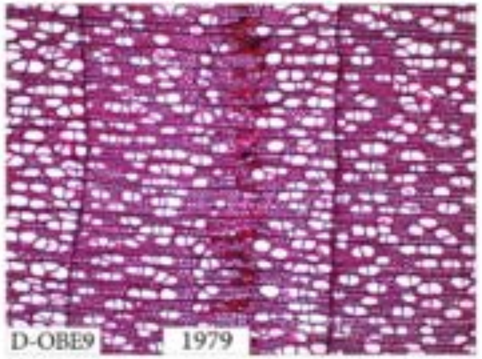
modified from
Nolin et al., 2021b – Journal of Hydrology

DIFFUSE-POROUS TREE SPECIES



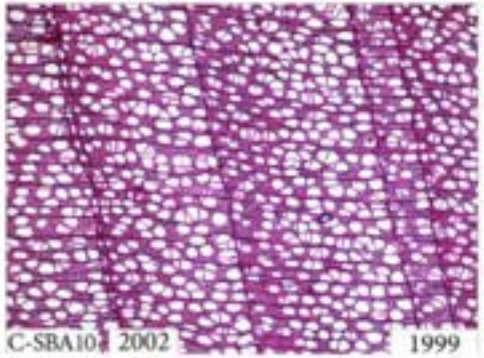
Density fluctuations in the growth ring formed directly after flash flood wounding in *Alnus glutinosa* from the Arroyo Cabrera torrent, Spain.

Ballesteros et al., 2010 - Tree Physiology



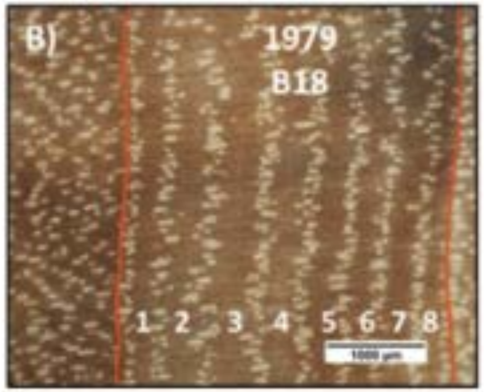
Anomalous cell anatomy in *Populus tremula* from the Ob River flood in 1979, Russia.

Meko et al., 2020 - The Holocene



Reduced tree-ring growth in *Salix alba* from the Ob River flood in 1999 and 2002, Russia.

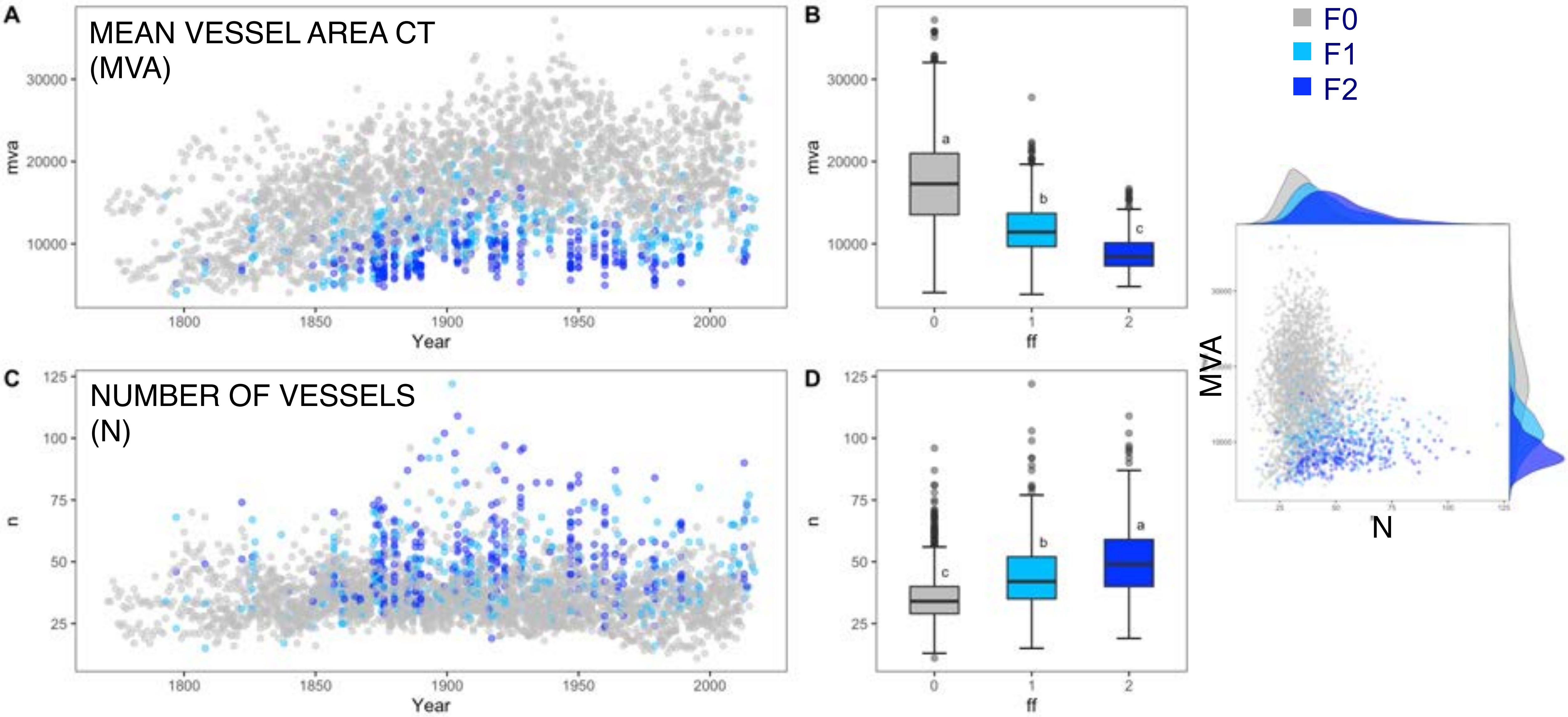
Meko et al., 2020 - The Holocene



Periodical tangential bands of vessels (PTBV) in *Populus tremuloides* from the Lake Duparquet flood in 1979, Canada.

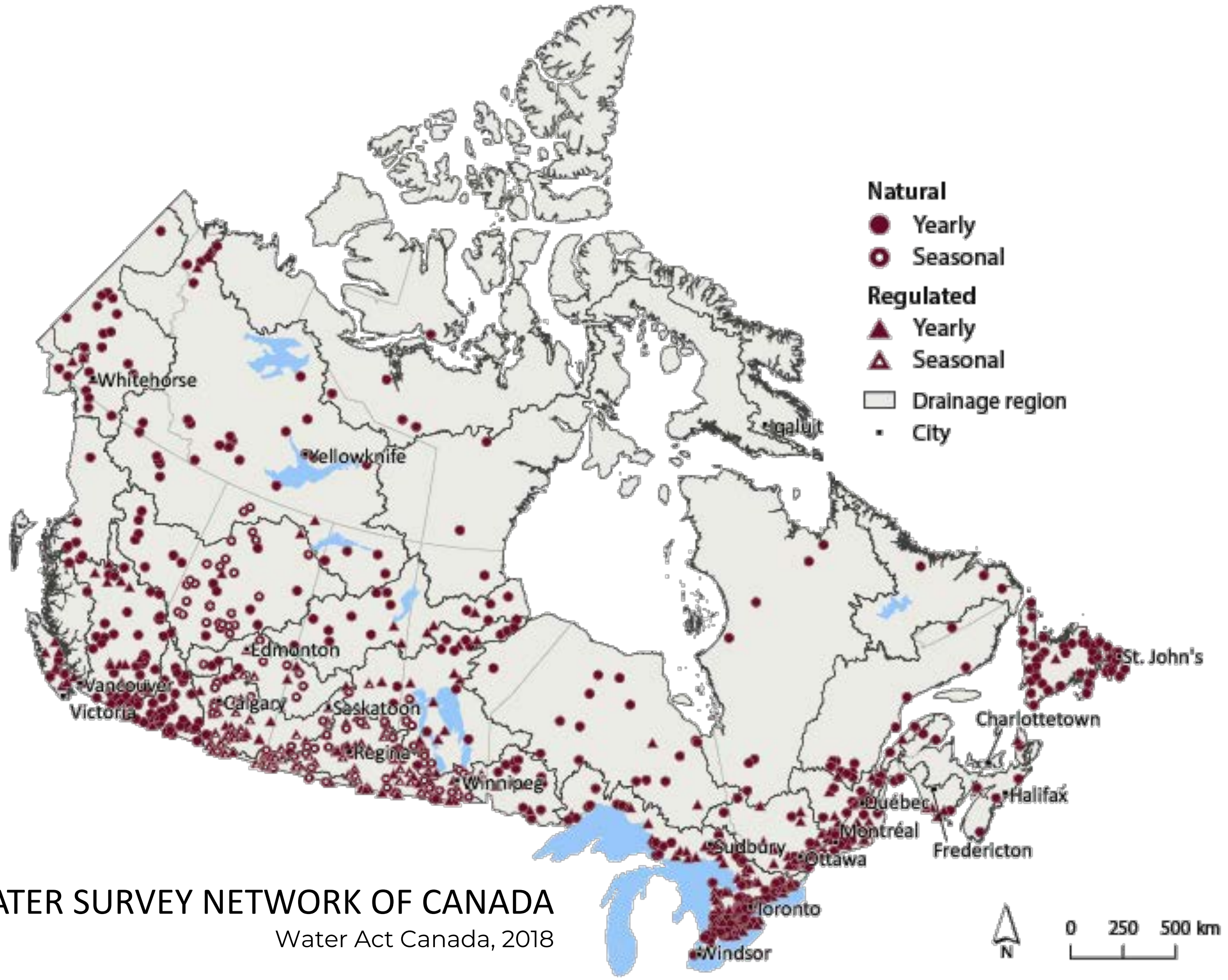
Tardif et al., 2021 - Dendrochronologia

Characterize flood rings in multiple riparian species

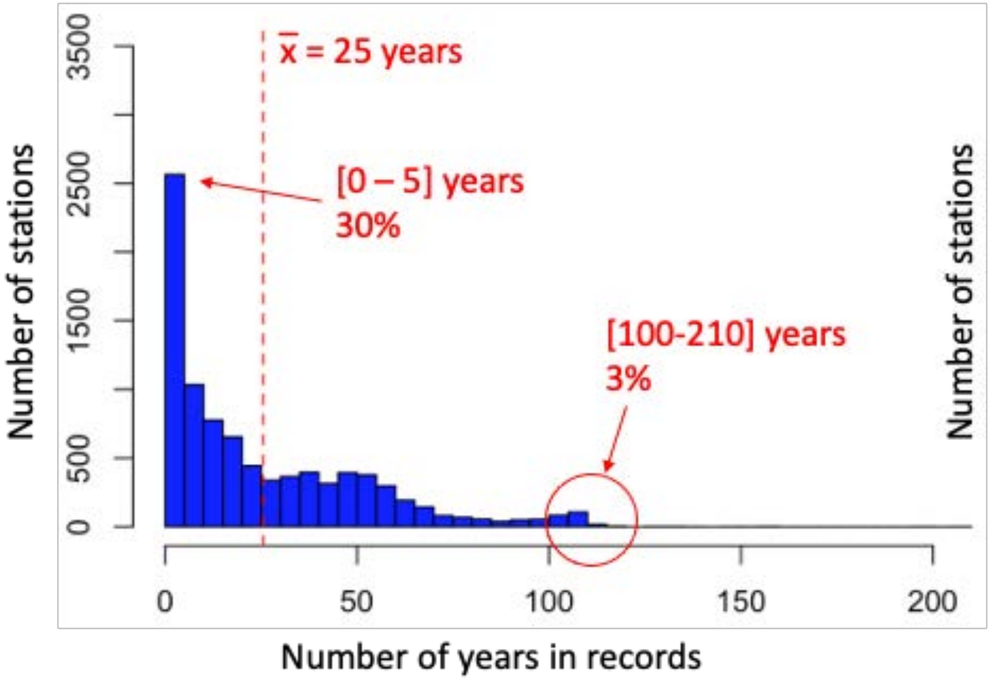


Develop a large-scale flood ring network

BLACK ASH = ~300 yrs
NATURAL + REGULATED RIVERS



WATER SURVEY NETWORK OF CANADA
Water Act Canada, 2018



Develop applications in flood-risk management : Flood frequencies

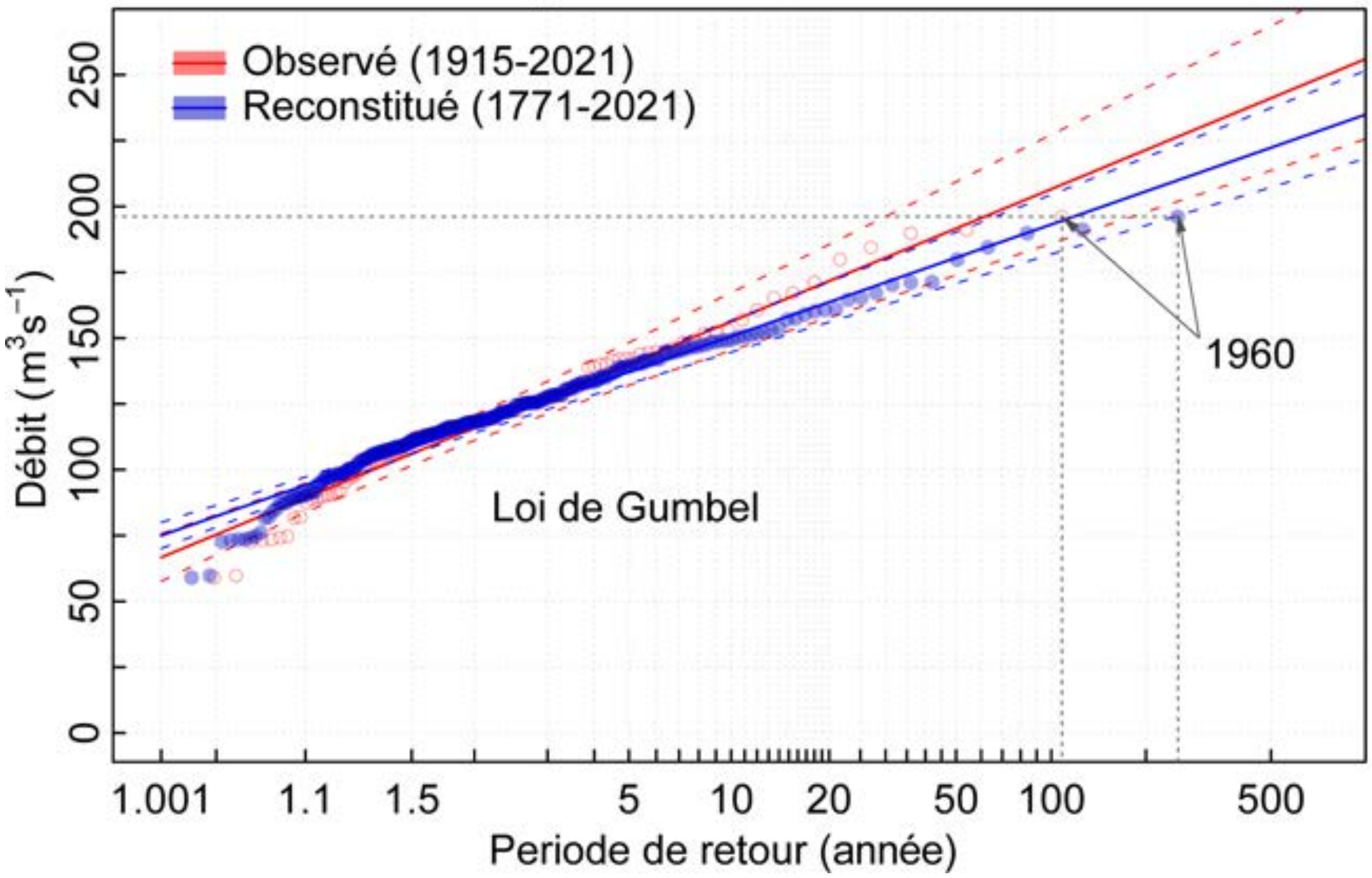
OBSERVATIONS

$$f = \frac{1}{100}$$

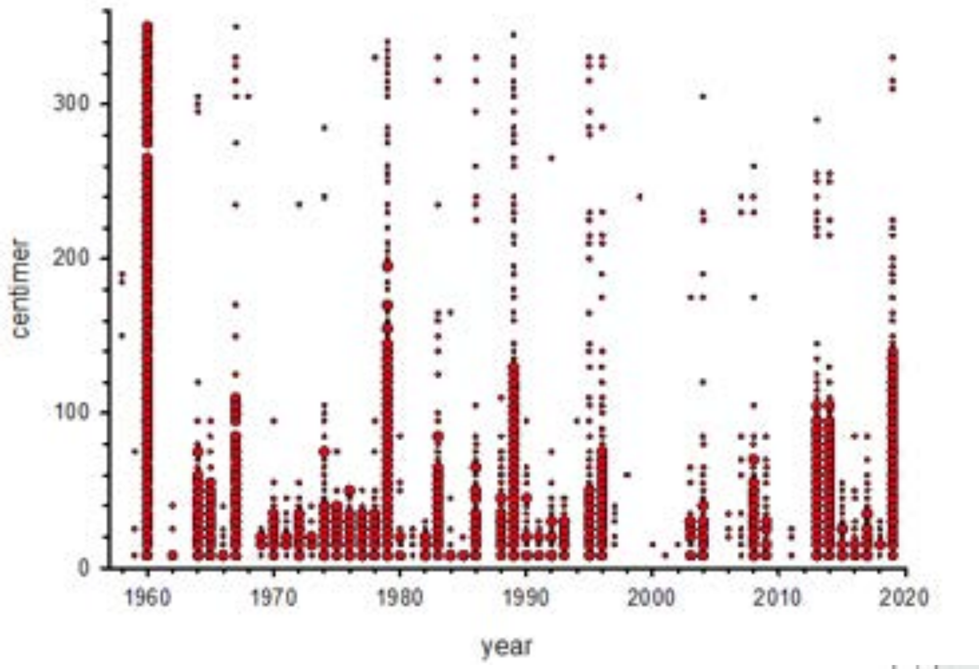
RECONSTRUCTION

$$f = \frac{1}{250}$$

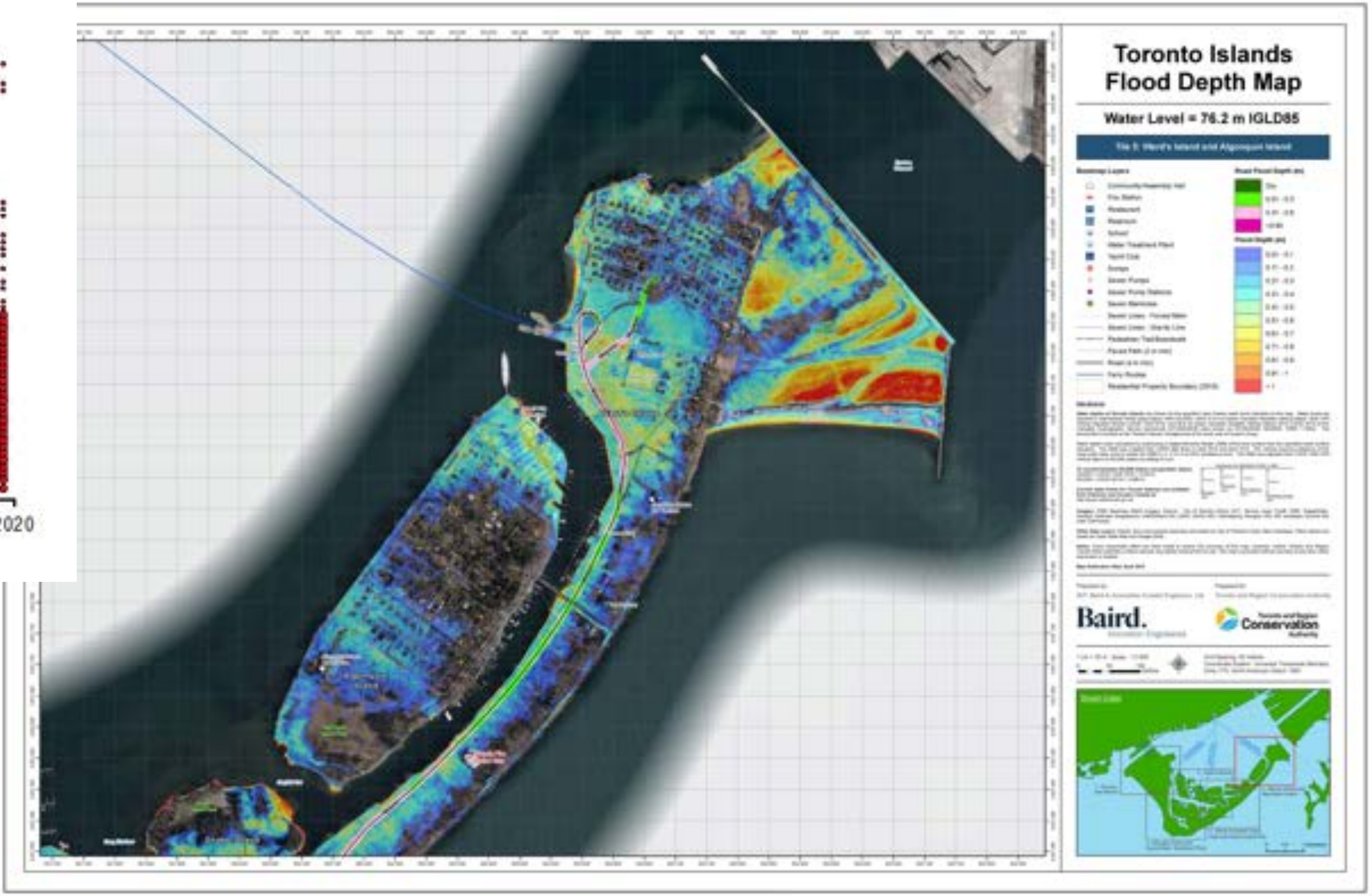
OBSERVED vs RECONSTRUCTED HARRICANA



Develop applications in flood-risk management : Flood depth map



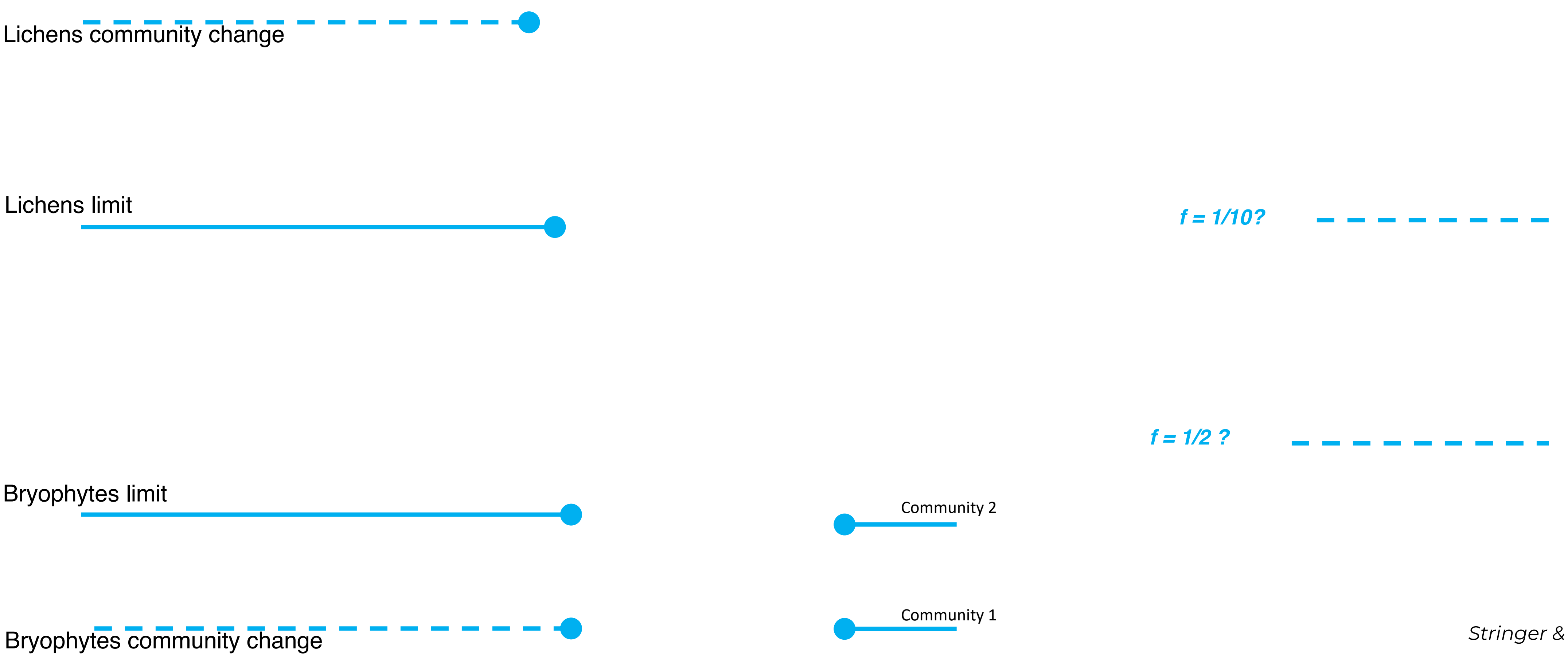
Tardif, unpublished data



https://ressources-naturelles.canada.ca/types-et-processus-de-cartographie-des-inondations/24265

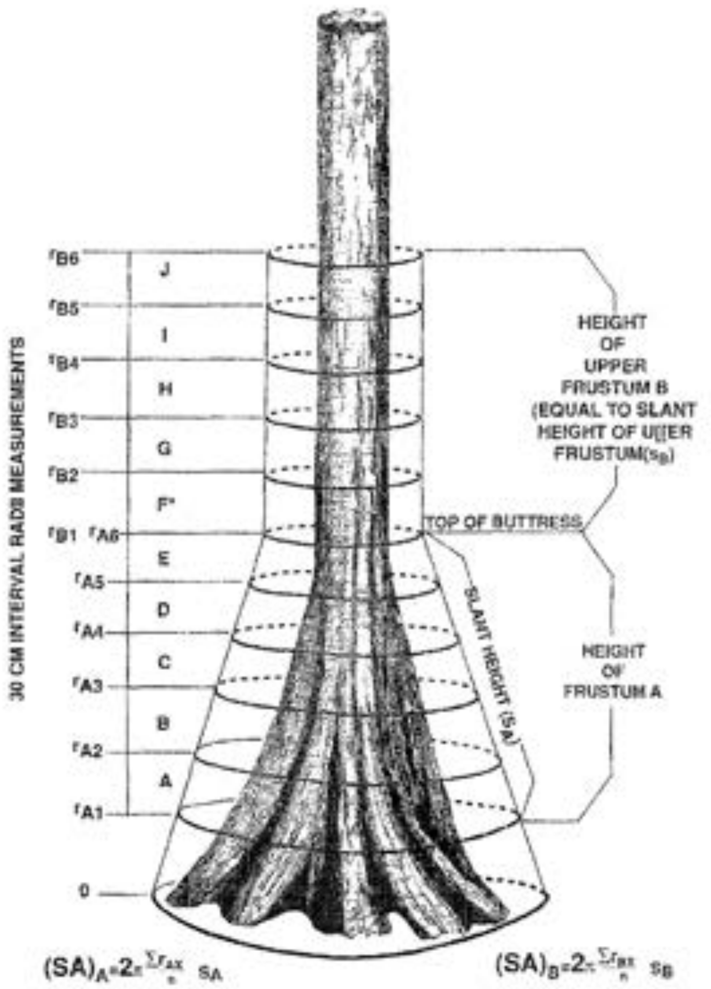
Calibration set : Harricana, Kinojévis, Duparquet + Ontario ?

+ Applications to flood depth and risks mapping

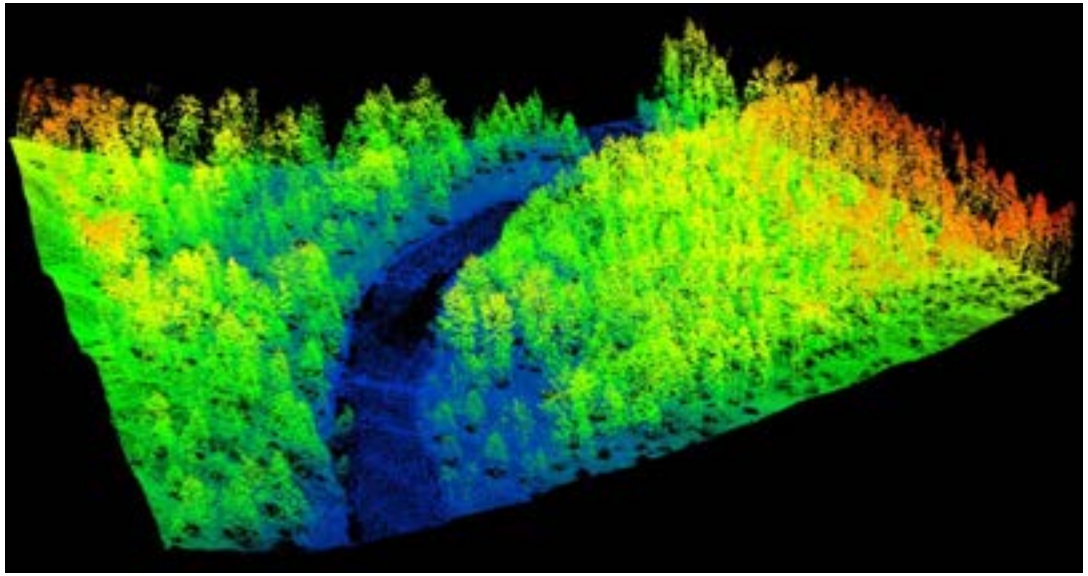


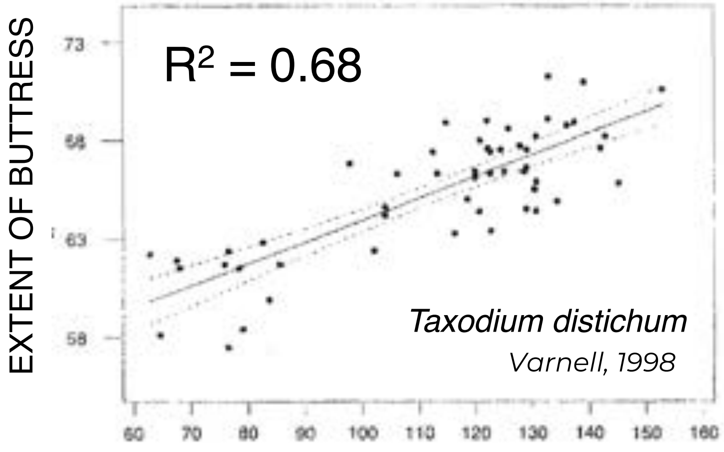
Stringer & Stringer (1974)

+ Applications to flood depth and risks mapping



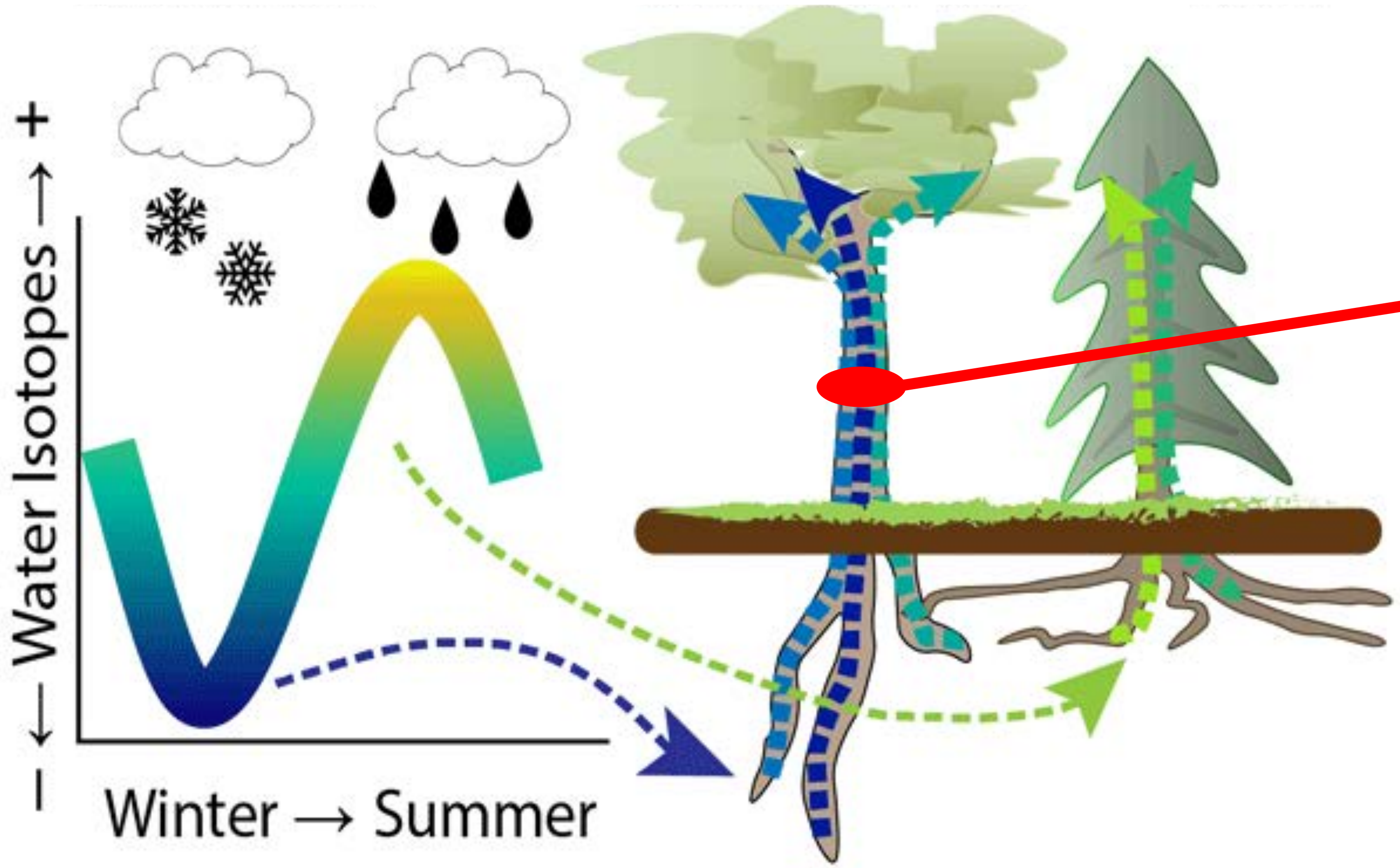
Taxodium distichum
Varnell, 1998





MEAN NUMBER OF DAYS PER YEAR OF INUNDATION
(1847–1995)

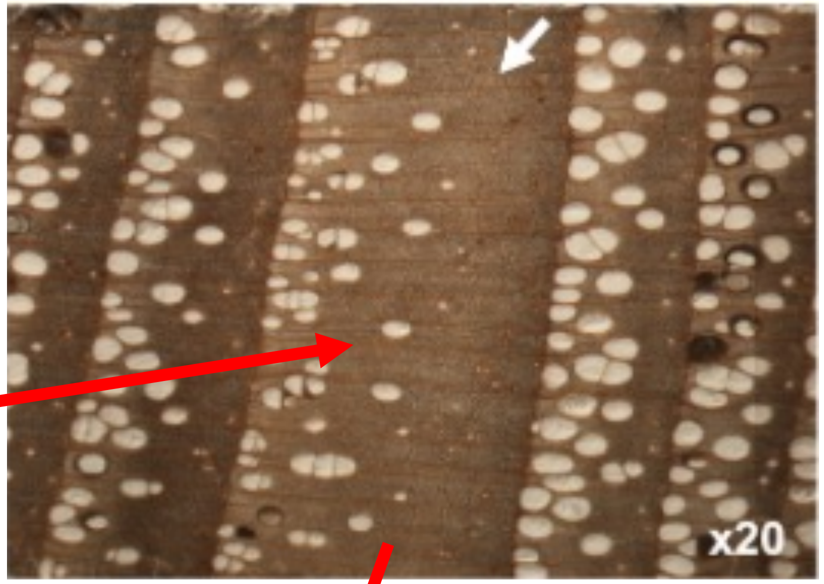
Reconstruct flood-water origins



SEASONNAL ORIGIN OF SOIL WATER USED BY TREES

Allen et al., 2019

FLOOD RING



δ^2H *Allen et al., 2019*

$\delta^{18}O$ *Ferrio et al., 2018 ; Rahman et al., 2022*

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