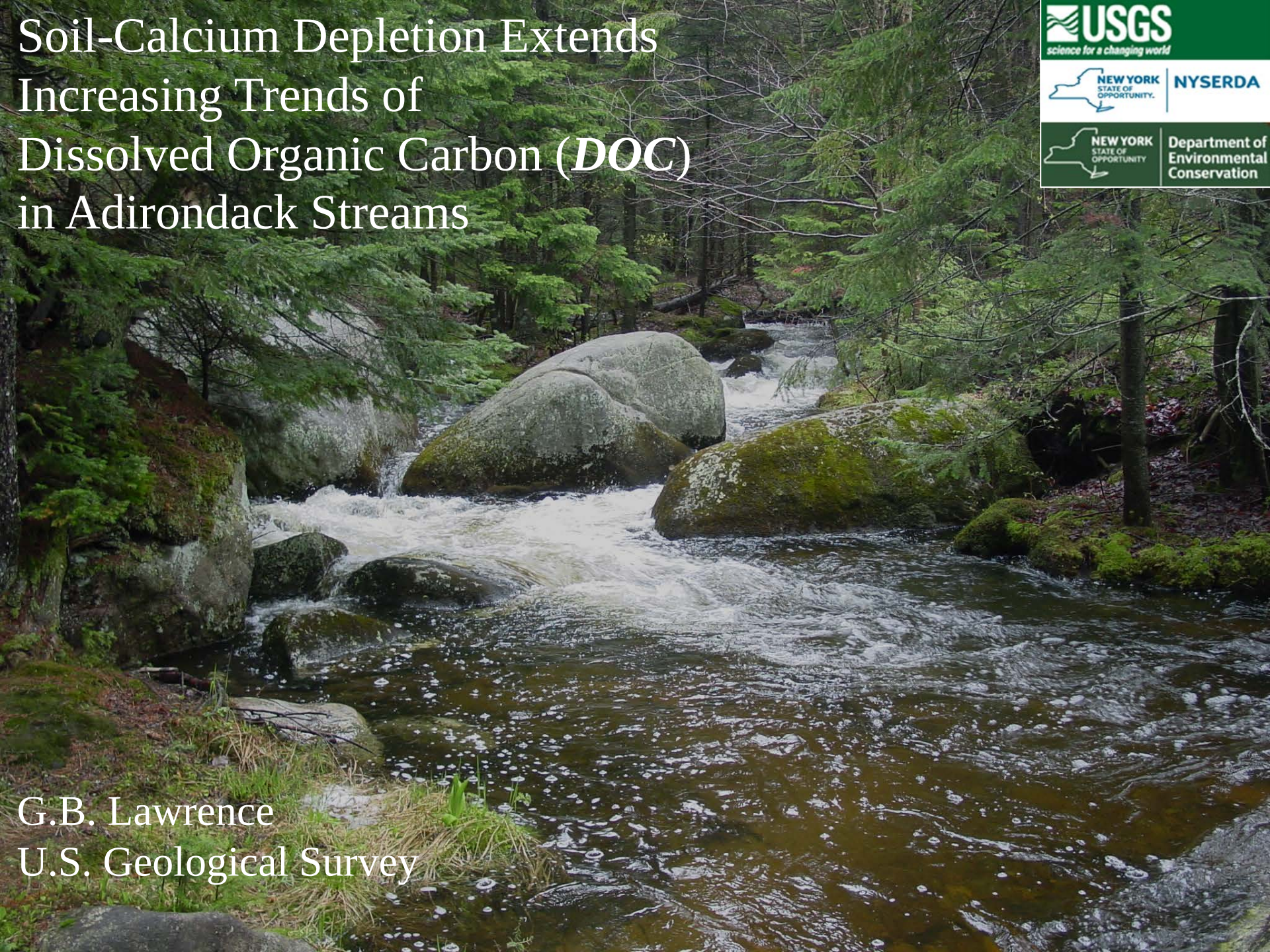
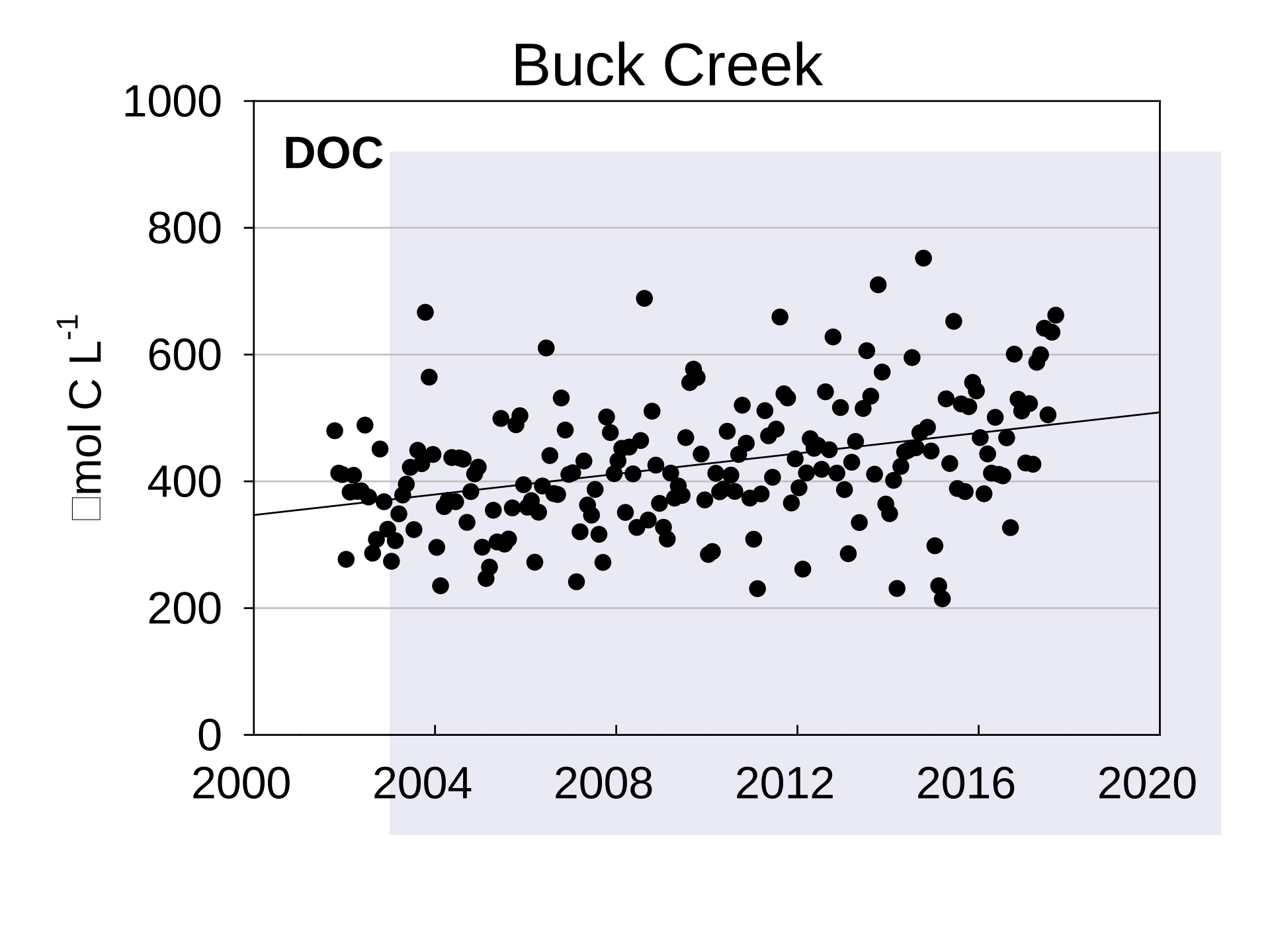
Soil-Calcium Depletion Extends Increasing Trends of Dissolved Organic Carbon (*DOC*) in Adirondack Streams

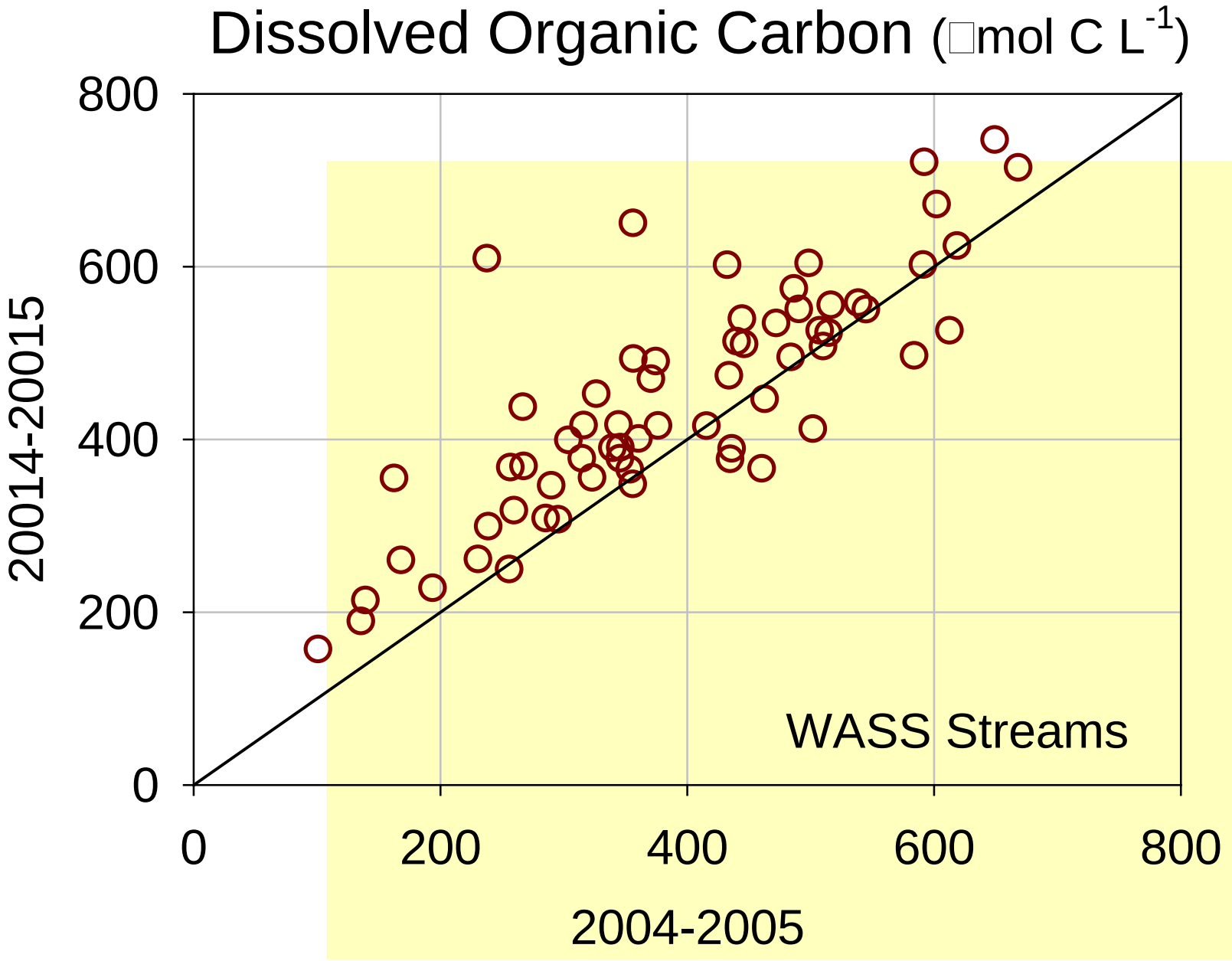


G.B. Lawrence
U.S. Geological Survey

What is the significance of increasing DOC?

1. Associated organic acidity lowers pH and ANC.
2. Browning effects light penetration and thermal regime of surface waters.
3. Dissolved organic matter represents a source of energy and nutrients in aquatic ecosystems.


Buck Creek
DOC
1000
800
600
400
200
0
□mol C L-1
2000
2004
2008
2012
2016
2020

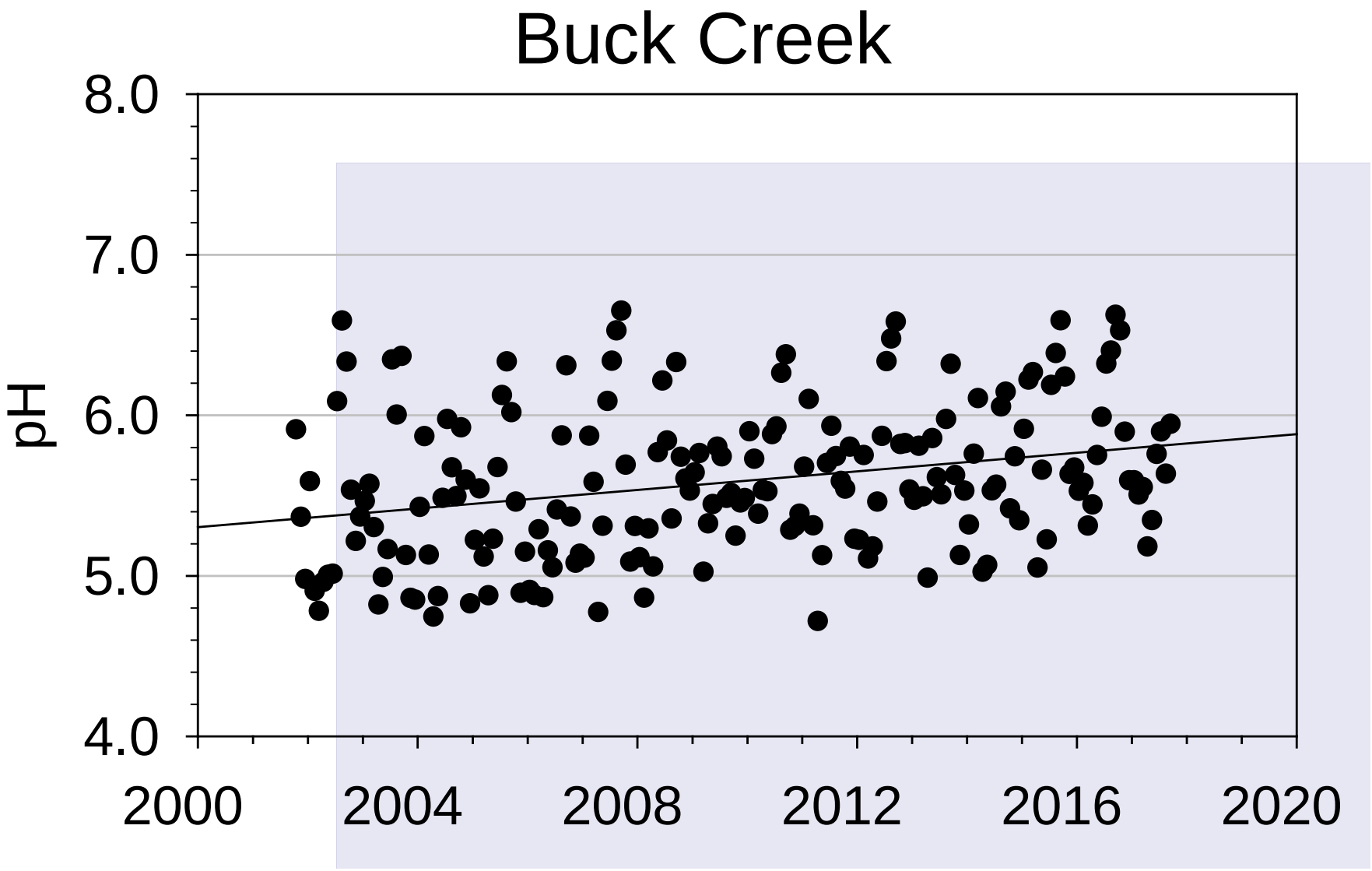

Dissolved Organic Carbon (□mol C L-1)
800
600
400
200
0
20014-20015
0
200
400
600
800
2004-2005
WASS Streams

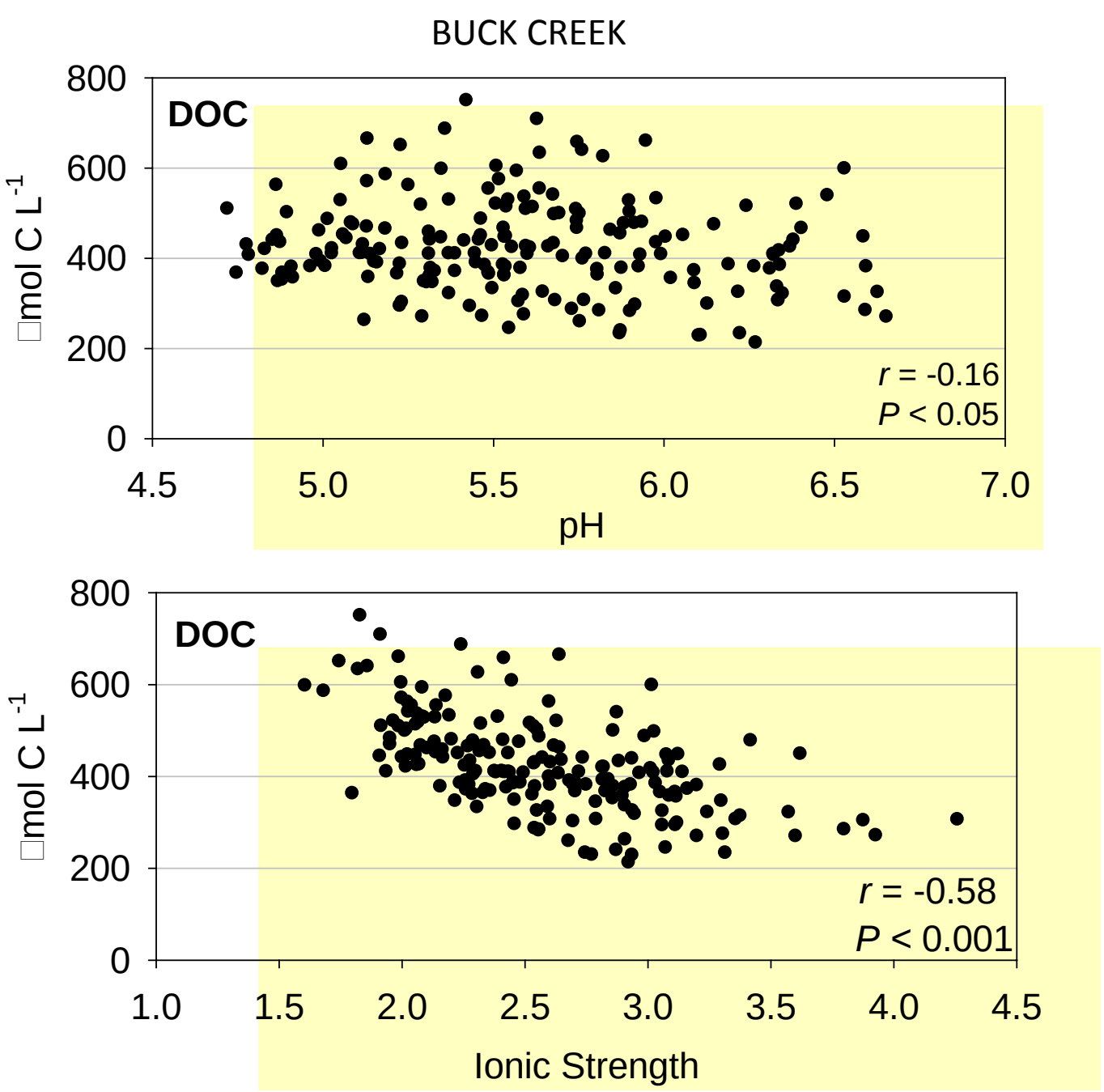
Chemical mechanisms for increasing DOC with decreasing acidic deposition

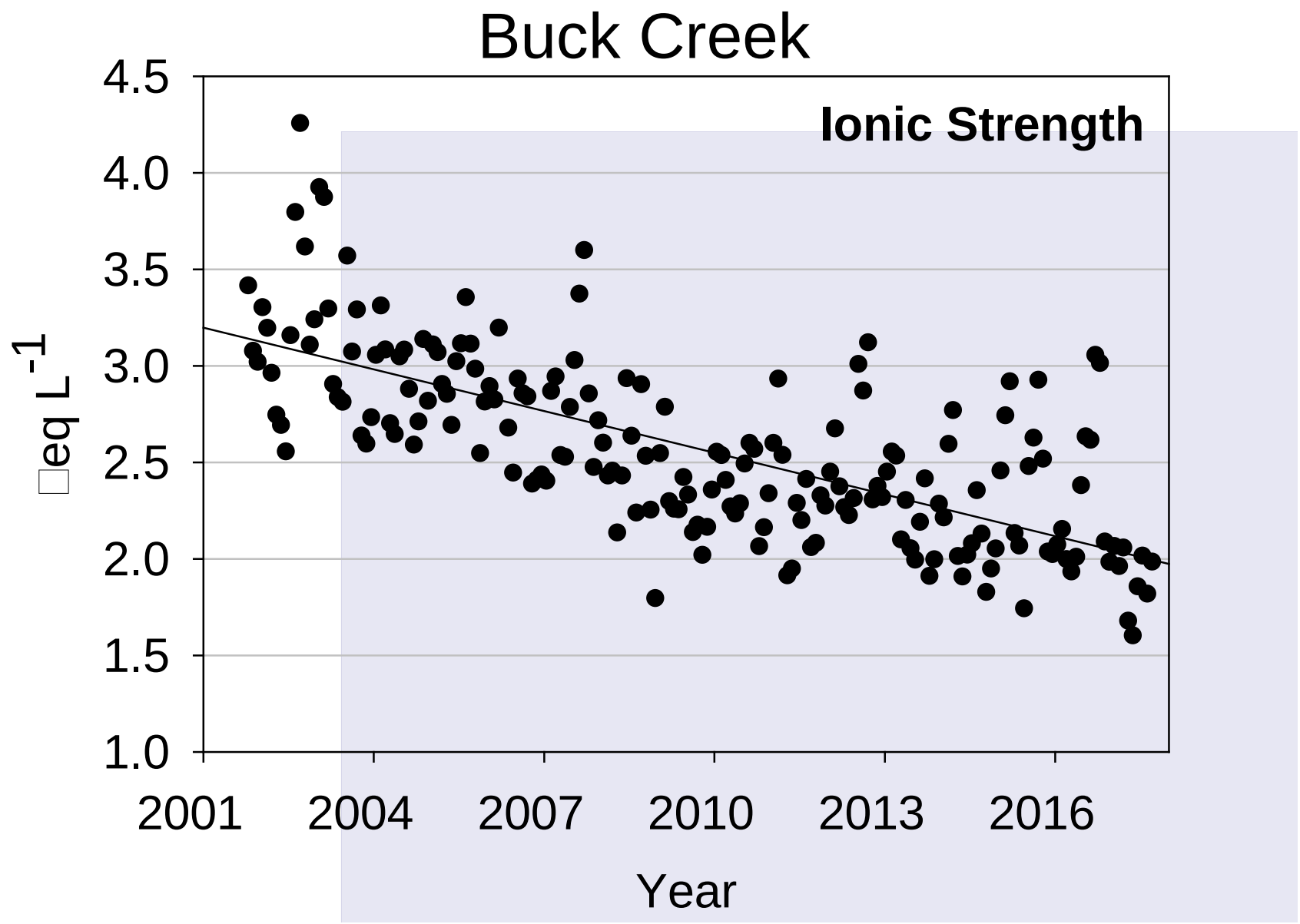
1. *Increases* in soil water pH.

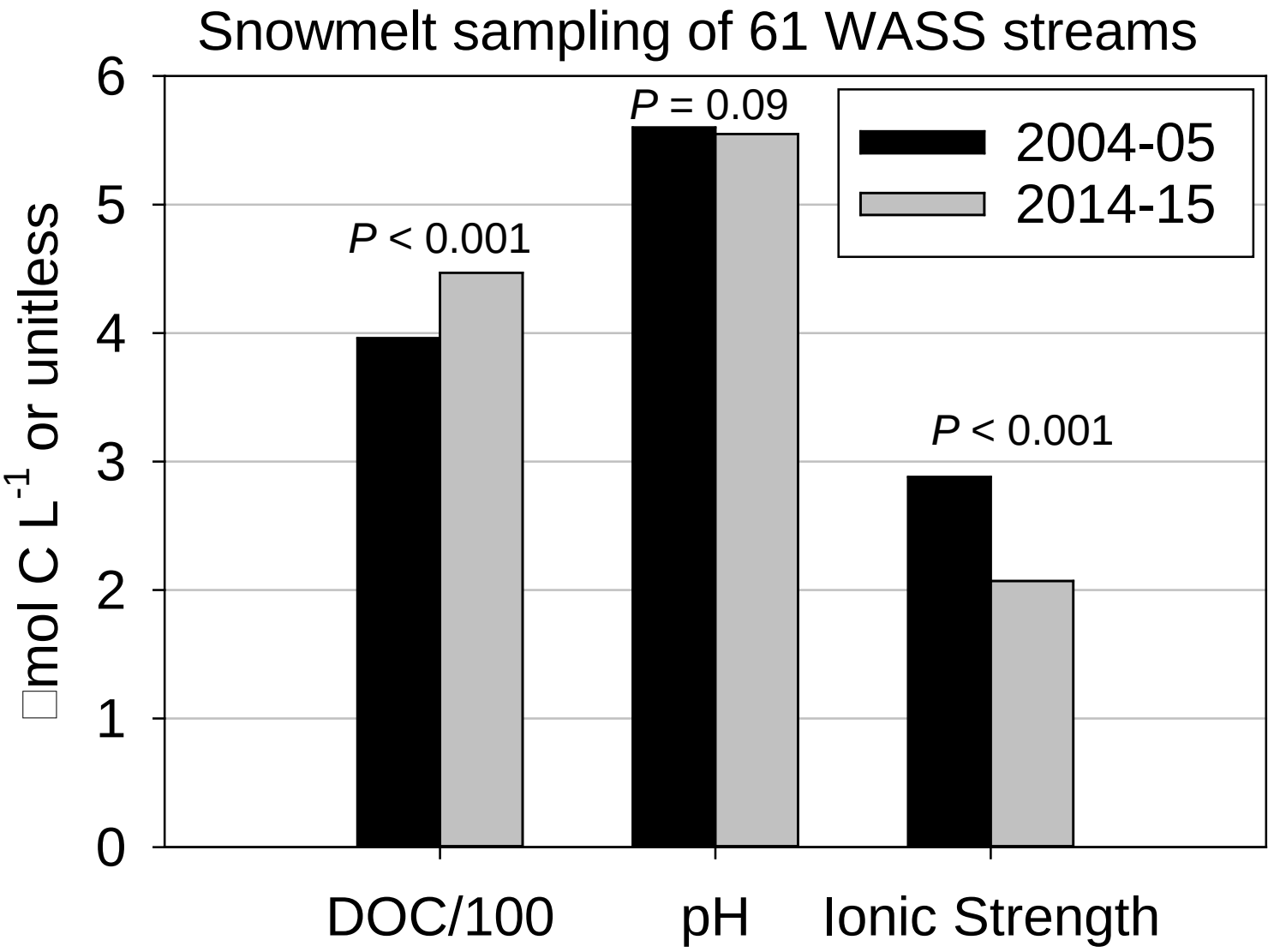
2. *Decreases* in soil water ionic strength (total charge).

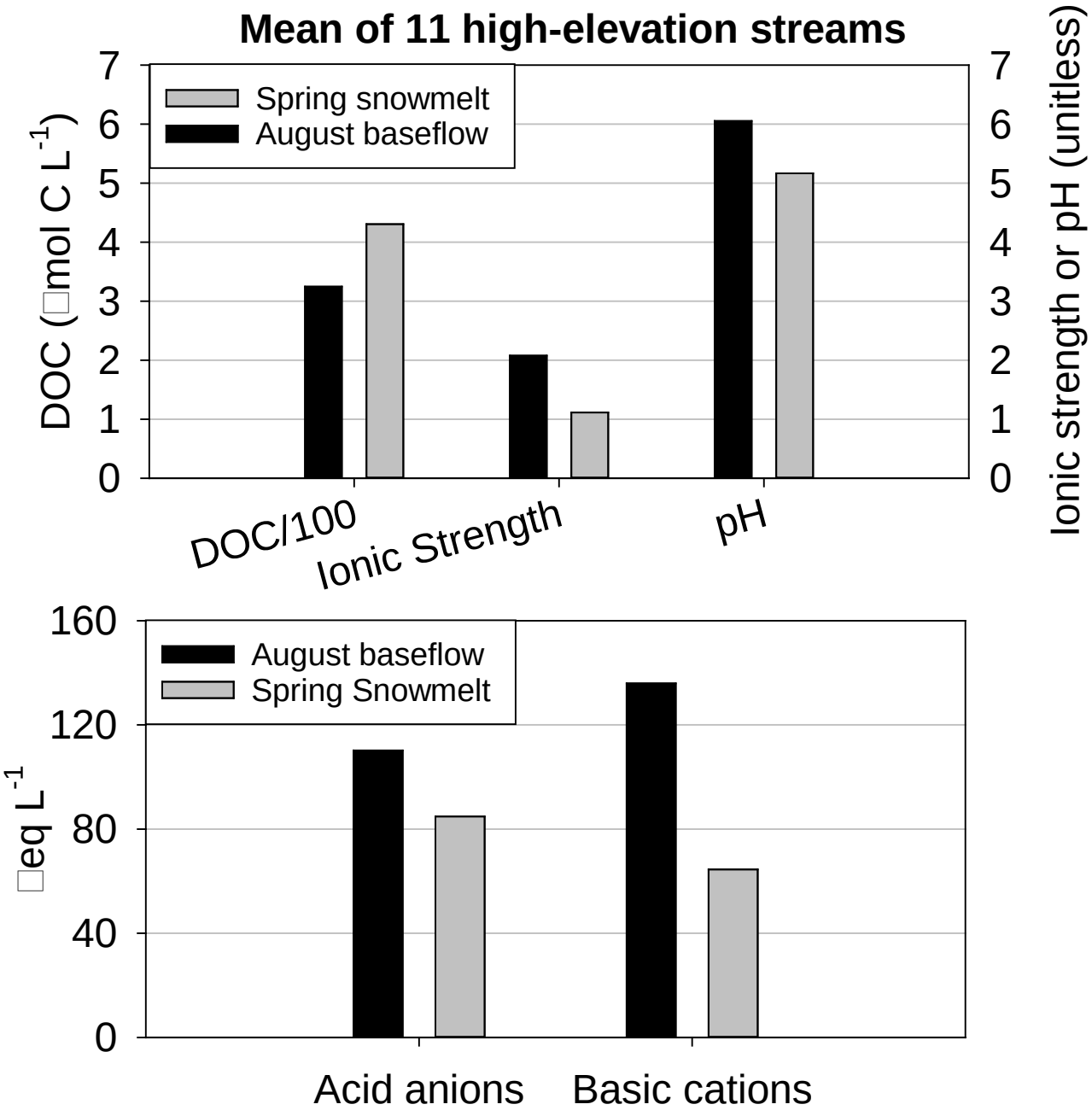
Both increase the solubility of organic matter, which facilitates the hydrologic transport from soils to streams.

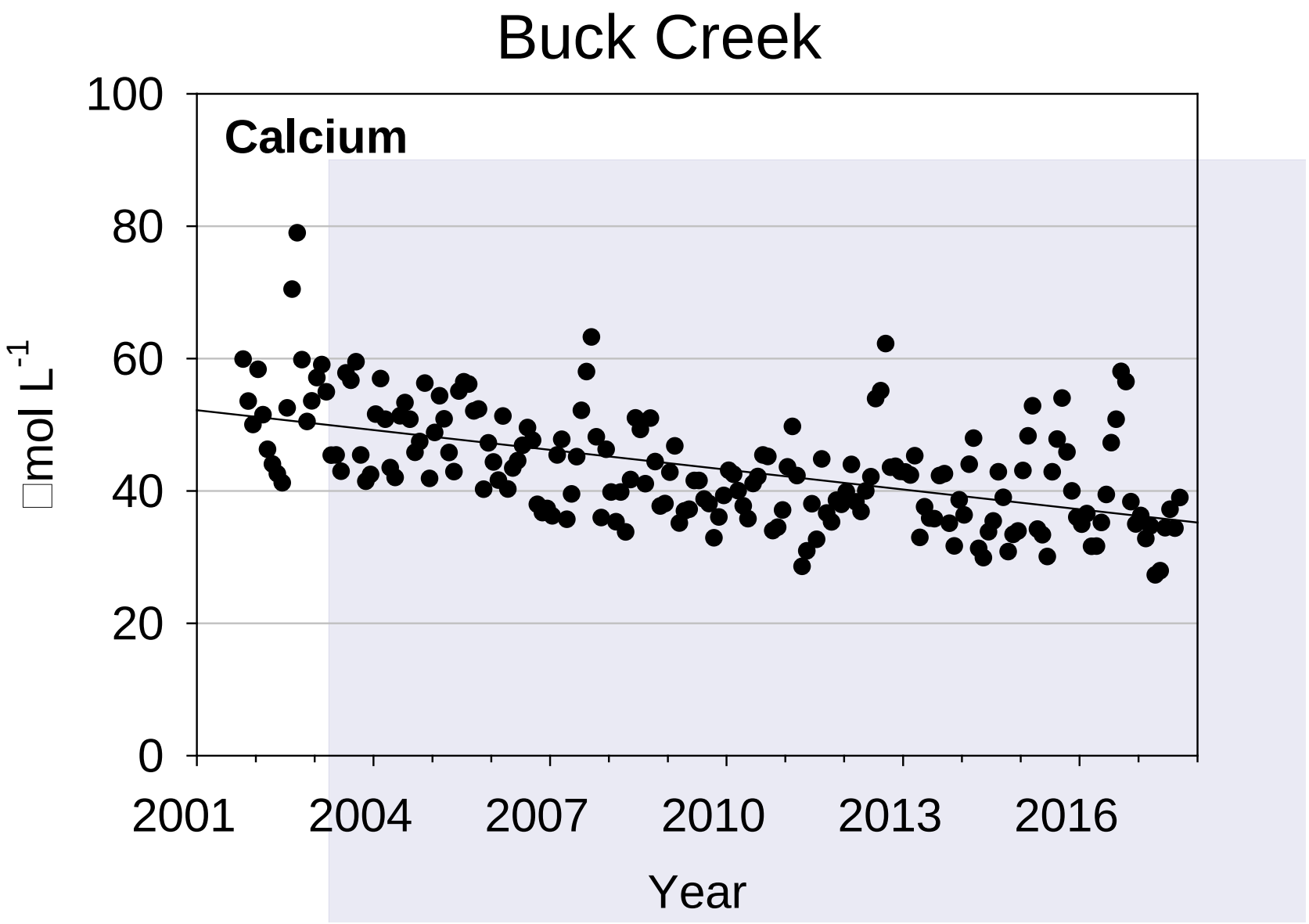

Buck Creek
8.0
7.0
6.0
5.0
4.0
pH
2000
2004
2008
2012
2016
2020

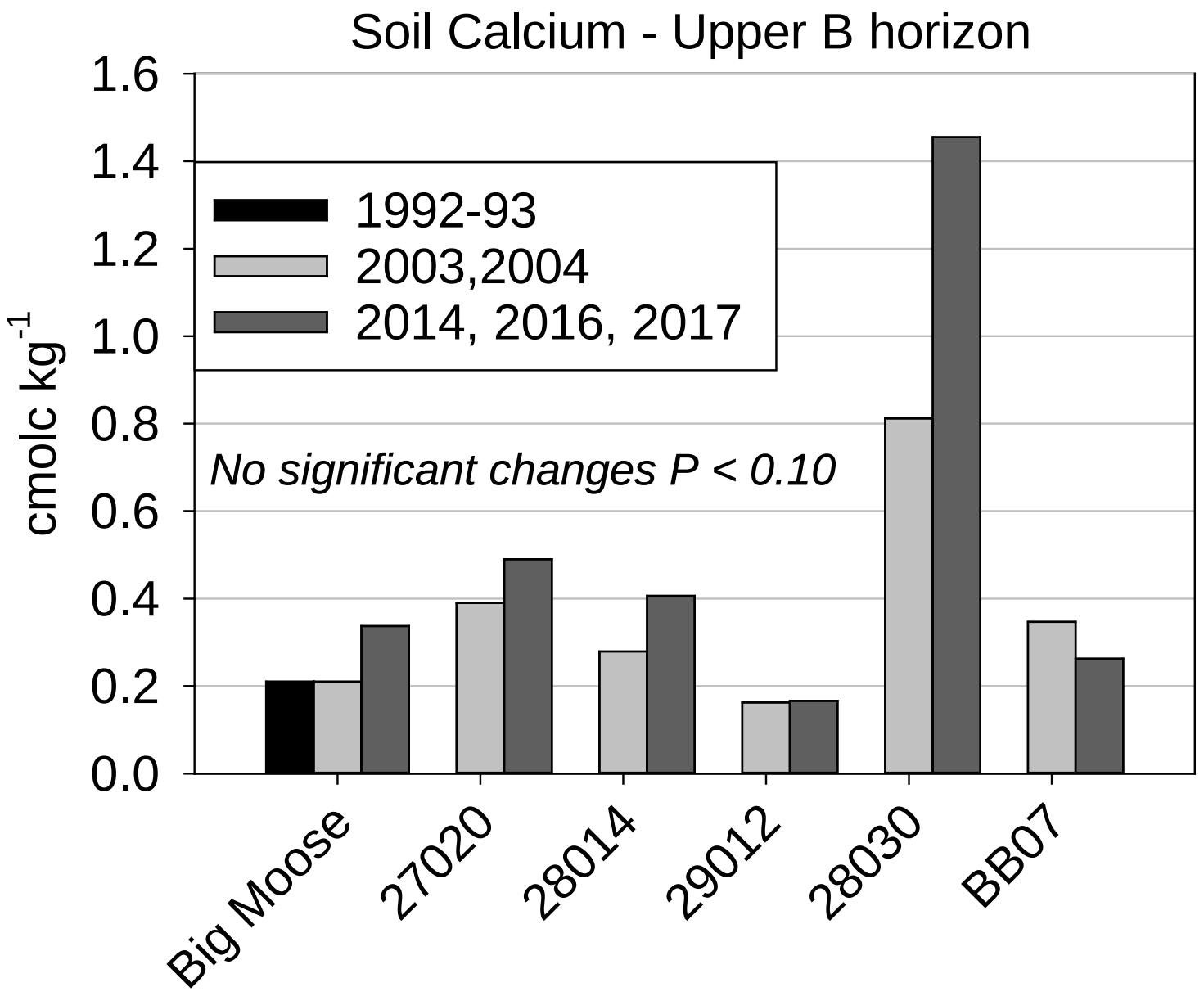

BUCK CREEK
DOC
800
600
400
200
0
□mol C L-1
r = -0.16
P < 0.05
4.5
5.0
5.5
6.0
6.5
7.0
pH
DOC
800
600
400
200
0
□mol C L-1
r = -0.58
P < 0.001
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
Ionic Strength

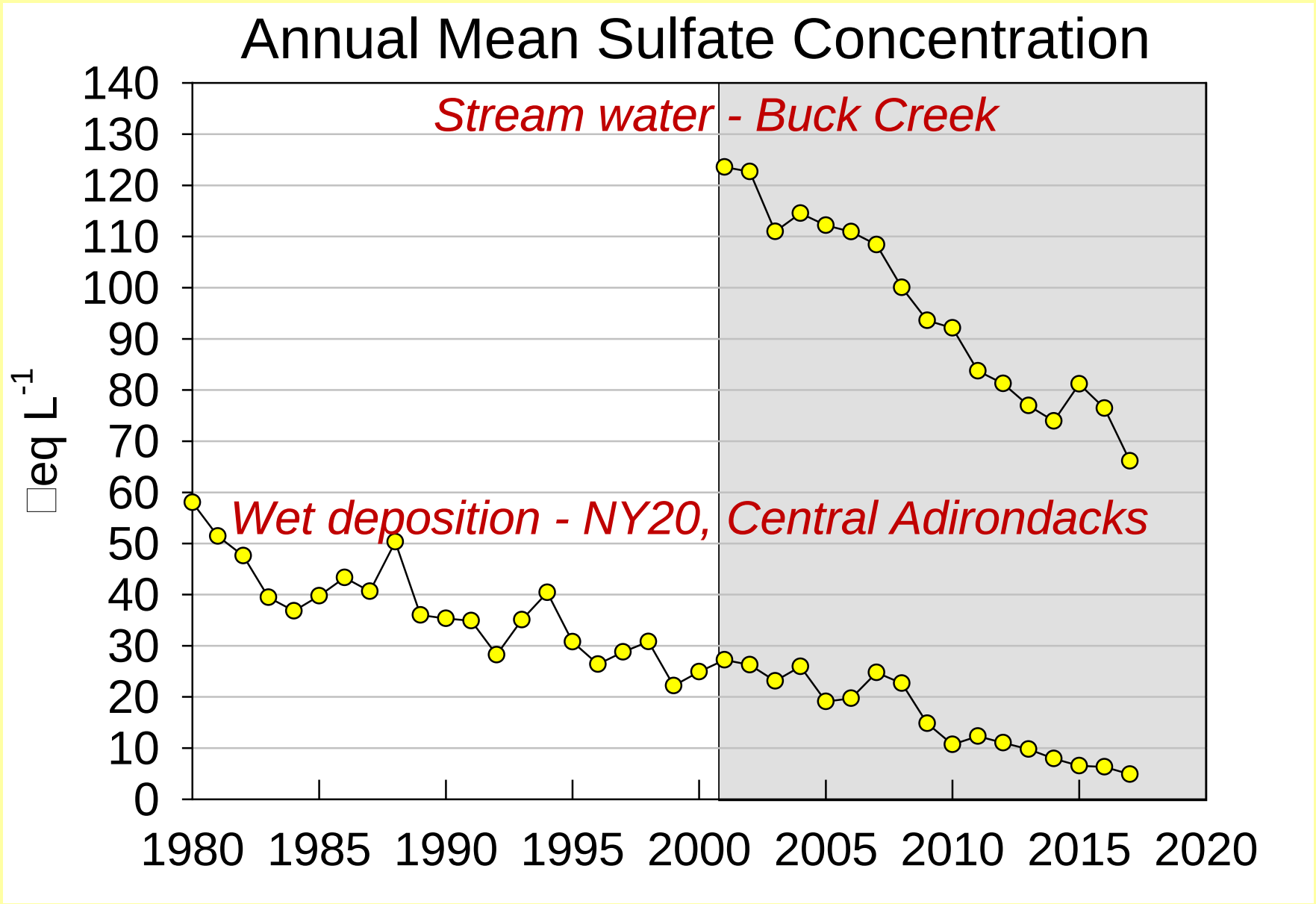

Buck Creek
Ionic Strength
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
□eq L-1
2001
2004
2007
2010
2013
2016
Year


Snowmelt sampling of 61 WASS streams
□mol C L-1 or unitless
6
5
4
3
2
1
0
P < 0.001
P = 0.09
P < 0.001
2004-05
2014-15
DOC/100
pH
Ionic Strength


Mean of 11 high-elevation streams
Spring snowmelt
August baseflow
DOC (□mol C L-1)
Ionic strength or pH (unitless)
0
1
2
3
4
5
6
7
DOC/100
Ionic Strength
pH
August baseflow
Spring Snowmelt
□eq L-1
0
40
80
120
160
Acid anions
Basic cations


Buck Creek
Calcium
100
80
60
40
20
0
□mol L-1
2001
2004
2007
2010
2013
2016
Year


Soil Calcium - Upper B horizon
cmolc kg-1
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1992-93
2003,2004
2014, 2016, 2017
No significant changes P < 0.10
Big Moose
27020
28014
29012
28030
BB07


Annual Mean Sulfate Concentration
Stream water - Buck Creek
Wet deposition - NY20, Central Adirondacks
□eq L-1
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1980
1985
1990
1995
2000
2005
2010
2015
2020

What does this mean for future DOC concentrations?

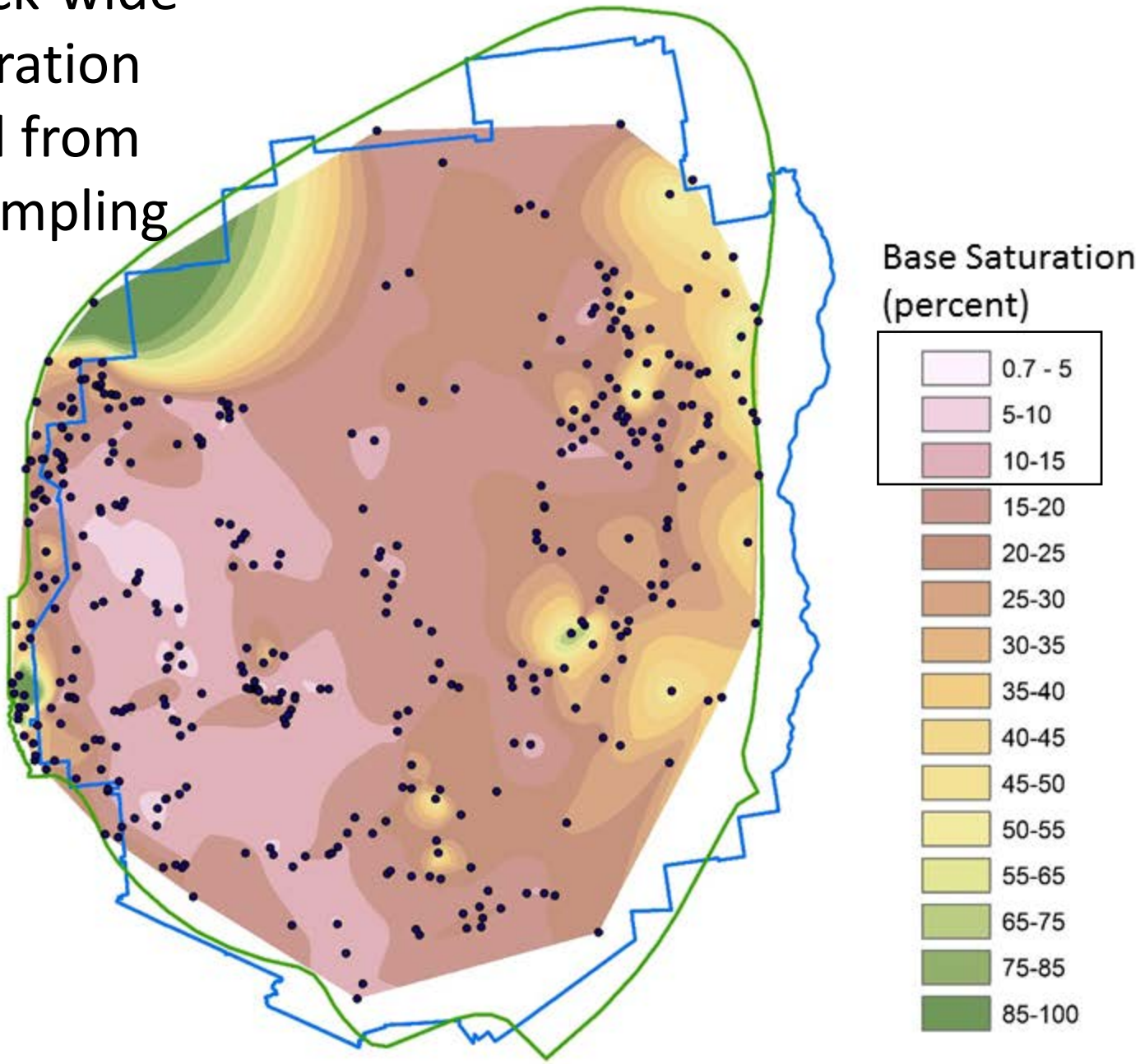
1. Currently, dilution is the primary cause of increasing DOC.

2. Dilution will continue from decreasing stream SO_4^{2-} without improvement in calcium availability.

3. DOC concentrations will continue increasing, perhaps to levels that exceed preindustrial levels.

4. What about climate change effects on soil-carbon mobility?

Adirondack-wide base saturation estimated from stream sampling



Because these soils have been depleted of Ca, it seems likely that DOC is not returning to preindust, but actually exceeding preindustrial, and not clear when conc will level off, then we may have the effect of climate change kicking in.

Stream water will continue to become more dilute and DOC will continue to increase as SO4 concentrations decrease (which is expected) until Ca availability begins to increase (rate at which Ca is produced by weathering needs to exceed leaching rate). Prior to acid rain, Ca built up slowly in these low Ca systems under conditions of very low leaching by a combination of organic anions and bicarbonate.