Trace Gas Concentrations in Streams - Early Warning Indicators of Stream Impairment?

RogerA.Burke[1] andJonMolinero[2]

[1]OfficeofResearchandDevelopment,NationalExposureResearchLaboratory,Athens,Georgia

[2]NationalResearchCouncil,Athens,Georgia

Year of Water: Thirty Years of Progress Through Partnering

The Problem:

Headwaterstreamsandtheirwatershedsarea criticalpartofrivernetworksthatprovidevaluable ecosystemservicessuchasorganicmatter processingandnutrientretentionwhichprovide importantresourcestodownstreamecosystemssuch aslakesandrivers.

Becauseoftheirsmallsize,headwaterstream ecosystemfunctioniseasilyimpairedbylanduse changesandexcessorganicwasteinputsassociated withagricultural,residential,andindustrial development.

Forthesereasons,itiscriticalthatheadwater streamsreceivemoreintensivestudyandgreater protection.

Background:

ConcentrationsofthetracegasesN_2O,CO_2,andCH_4 instreamsareusefulindicatorsoforganicmatter decompositionandnutrientcyclingprocessesin aquaticsystems.

Becauseexcessinputsoforganicwastescanimpair organicmatterprocessingandnutrientretentionin streams,tracegasconcentrationsshouldprovide valuableinformationaboutstreamecosystem functiontowaterqualitymanagersandregulators.

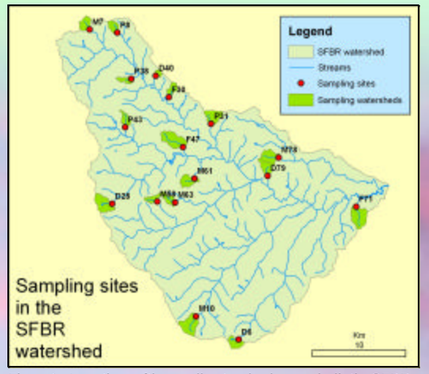


Figure1. LocationsofthesmallwatershedssampledintheSFBR.

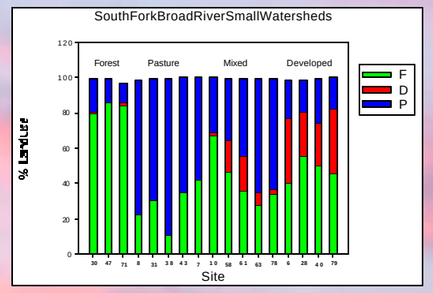


Figure2. LanduseofthesmallSFBRwatershedsthatwere sampled

Approach:

SeventeenheadwaterwatershedswithintheSouth ForkBroadRiver(SFBR)watershedrangingfrom0.5 to3.4km^2 wereselected(Figure1).

Percentagesofforestedland,agriculturalandpasture land,residentialareas,wetlandsandopenwater surfaceswithinthesewatershedswerecalculated fromtheNationalLandCoverDatadatabaseandare shownin Figure2.

WemeasuredconcentrationsofthetracegasesN_2O, CO_2andCH_4,nutrients,dissolvedoxygen,and dissolvedorganiccarbon(DOC),andalkalinity,and conductivity,flowrate,andtemperatureinGeorgia Piedmontfirstorderstreamsonamonthlybasisfrom January2002untilMarch2003.

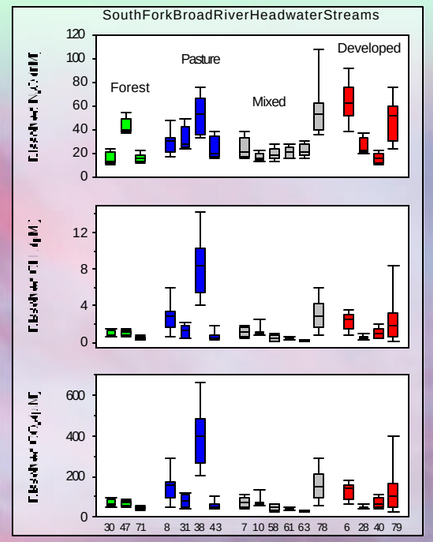


Figure3. TracegasconcentrationsinthesmallSFBRstreams

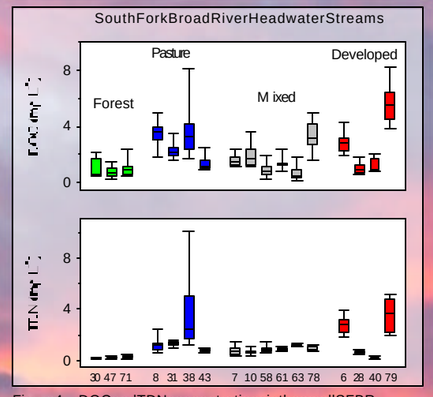


Figure4. DOCandTDNconcentrationsinthesmallSFBR streams

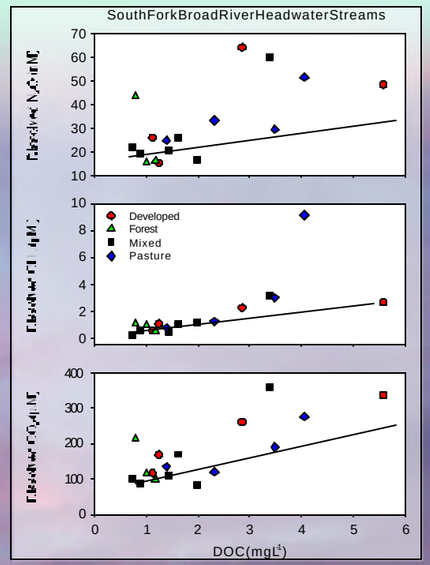
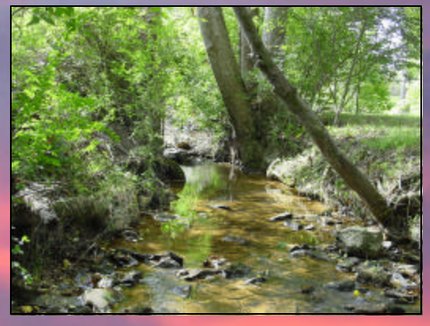
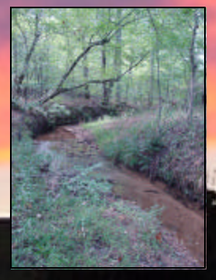
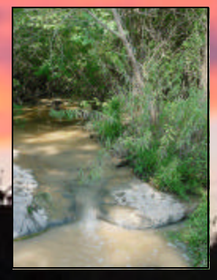


Figure5. MeanDOCconcentrationvs.meantracegas concentrationsinsmallSFBRstreams







Objective

Theobjectiveofthisresearchistodevelopeasily measuredindicatorsofheadwaterstreamecosystem functionandresponsetostressorssuchasexcess organicwasteandnutrients.

ResultsandDiscussion

TheconcentrationsofN$_2$O, CO$_2$,andCH$_4$,andof DOCandtotaldissolvednitrogen(TDN)measuredin the17watershedsoverthecourseofthestudyare showninFigures3and4.Manyofthestreamsthat drainwatershedswithsubstantialresidentialor pasturelandusesexhibitelevatedtracegas,DOC, andTDNconcentrationscomparedtostreams drainingforestedwatersheds(Figures3and4). ElevatedstreamDOCandTDN levelsprobably reflectinputsoforganicwastesfromsepticsystems and/oranimalagricultureandfertilizer. MeanstreamconcentrationsofN$_2$O,CH$_4$,andCO$_2$ allexhibitedsignificantpositivelinearcorrelations withmeanstreamDOCconcentration(Figure5),and alsowithmeanstreamTDNconcentration. The positiverelationshipsbetweenstreamtracegas concentrationsandDOCandTDNconcentrations suggestthattracegasconcentrationscouldbe usefulindicatorsoforganicwastecontaminationof streams.

ExpectedImpact

ConcentrationsofN$_2$OandCH$_4$ attypicalstream levelscontainamountsofNandCthatareseveral ordersofmagnitudelessthantheNandCinTDN andDOC. Elevatedtracegasconcentrationsmay thusbesensitiveindicatorsoforganicand/ornutrient contaminationatlevelstoolowtobereflectedby TDNandDOC.Ourdatasuggestthat N$_2$O concentrationsaboveabout15nMandCH$_4$ concentrationsaboveabout1µMinsmallstreamsof theGeorgiaPiedmontmayindicatewatershed contaminationbynutrientsand/ororganicwastes. Thus,weexpectthatelevatedtracegas concentrationswillbeveryusefulindicatorsof incipientwatershedimpairment,whichwouldbeof valuetowaterqualitymanagersandregulators,in someinstances.

Partnering to Protect Human Health and the Environment