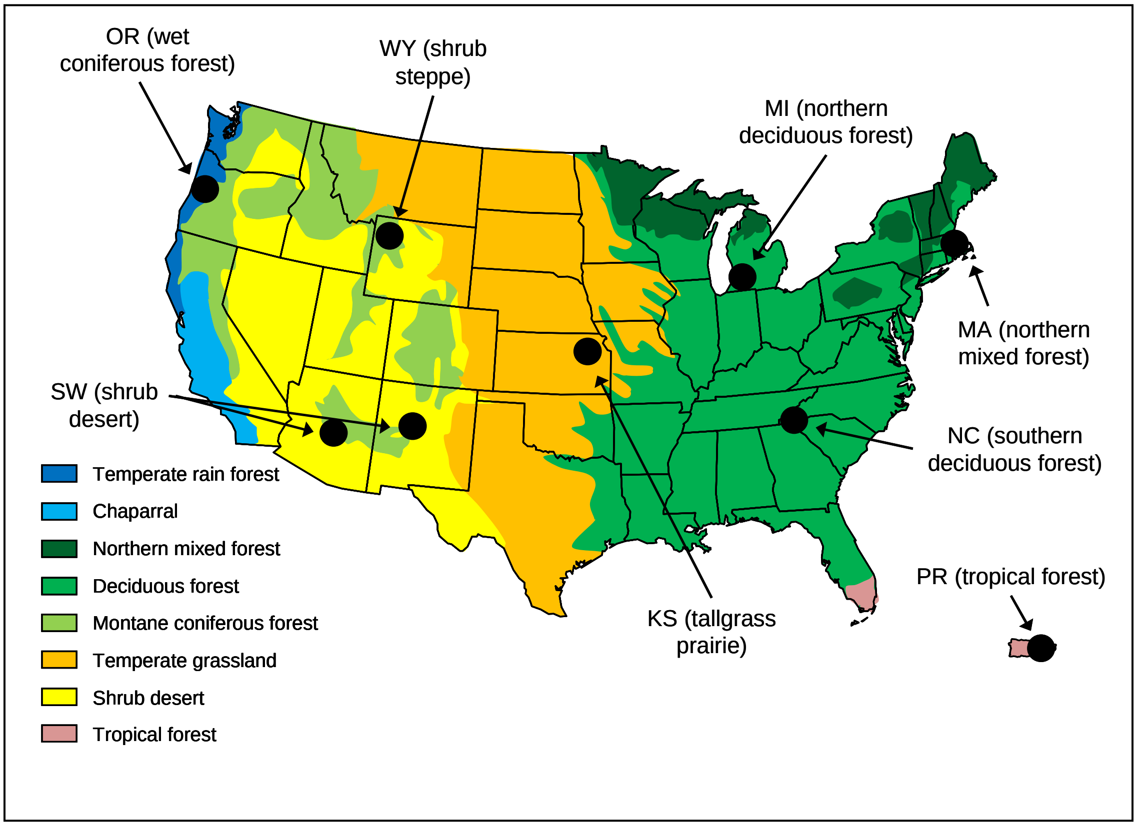
Supplementary Table 2: Definitions and units of stream network model terms.

Term	Definition	Units
Q_p	discharge in stream reach p	L^3T^{-1}
ΣQ_{p-1_i}	sum of upstream contributing discharge to stream reach p	L^3T^{-1}
Q_L	discharge from the adjacent drainage area to reach p	L^3T^{-1}
Q_w	water withdrawal from reach p	L^3T^{-1}
Q_{p+1_i}	discharge to the next downstream reach, p+1	L^3T^{-1}
$NO_3^-{}_p$	nitrate in stream reach p	MT^{-1}
$\Sigma\ NO_3^-{}_{p-1_i}$	sum of upstream contributing nitrate to stream reach p	MT^{-1}
$NO_3^-{}_L$	nitrate from the adjacent drainage area to s reach p	MT^{-1}
$NO_3^-{}_R$	nitrate removal from reach p	MT^{-1}
$NO_3^-{}_{p+1_i}$	nitrate to the next downstream reach p+1	MT^{-1}
A_p	adjacent drainage area of stream reach p; the area of the catchment draining directly to stream reach p	L^2
Y_p	per unit drainage area water yield to stream reach p	$L^3L^2T^{-1}$
L_p	Per unit drainage area loading rate to stream reach p	$ML^{-2}T^{-1}$
R	proportion of $NO_3^-{}_p$ removed via biological processing	%
υ_f	vertical velocity, or mass transfer coefficient	$L\ T^{-1}$
H_L	hydraulic load; the rate of water passage through the water body relative to the benthic surface area	$L\ T^{-1}$
l	stream reach length	L
a	width coefficient	unitless
b	width exponent	unitless

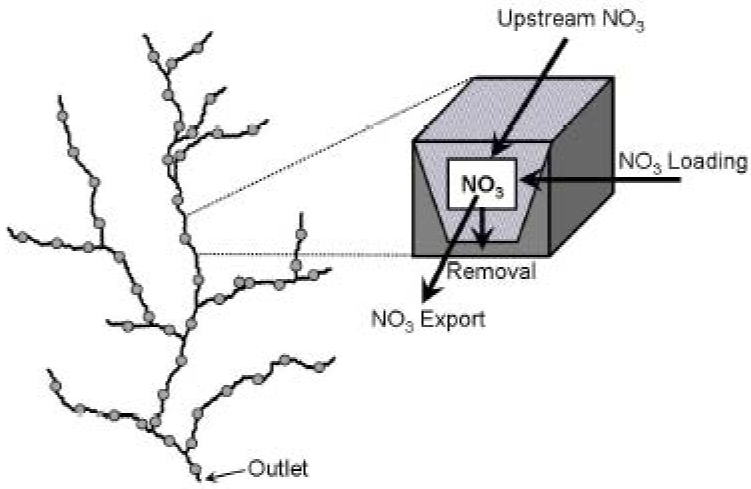
Supplementary Table 3: Methods used to derive parameters used in model runs.

Term	Description of method used to derived parameters
A_p	The area draining directly to each stream reach was derived from 30-meter raster digital elevation models (USGS National Elevation Data Set, available online at http://seamless.usgs.gov) in ArcView GIS software (Version 3.3) with the Spatial Analyst extension.
Y_p	Water yield (7.69×10^{-9} m s^{-1}) was held constant across all stream reaches and model runs. The value of water yield used was the average value of calculated water yield among 106 base flow discharge measurements taken from 2nd to 6th order streams across the biomes in which the LINX II experiments were conducted. Water yield was calculated for each discharge measurement by dividing observed discharge by catchment area.
L_p	Loading rates to streams (0.001 – 100 kg km^{-2} day^{-1}) were chosen such that they reproduced the range of observed concentrations in LINX-II experimental streams. Loading rates were constant for stream reaches within each model run, but varied between model runs.
l	Stream reach length was measured from the digital hydrography dataset for the stream network as described above using ArcView GIS software (Version 3.3).
A, b	The width coefficient and exponent were derived from measured width and discharge from the same sites used to derived water yield (Y_p). Non-linear regression was performed using R-Statistical Software (Version 2.2.1, R Foundation for Statistical Computing 2005; $r^2 = 0.74$, n = 102).
υ_f	The mass transfer coefficient was derived for both the constant and variable υ_f scenarios. The values for υ_f used in the constant scenarios were equal to the median values of observed υ_f values in the LINX-II experimental streams. The variable υ_f values were derived from the relationships between υ_f and NO_3^- concentration (Figures. 2a and 2b in main text).

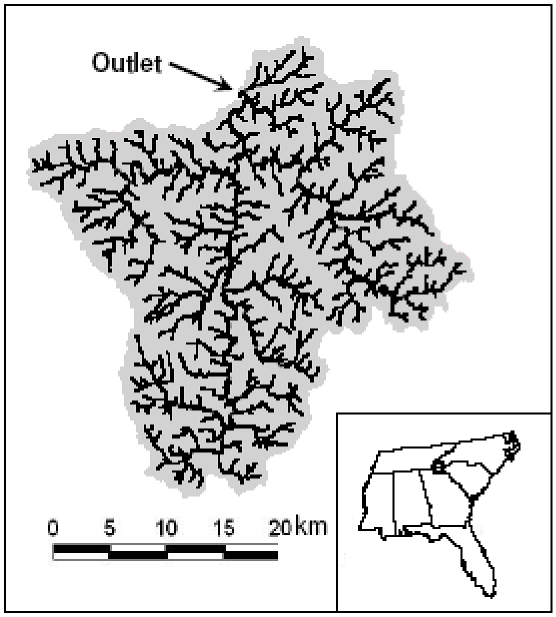
SUPPLEMENTARY FIGURES



Supplementary Figure 1: Regional sites of LINX II study streams and the biomes represented. With the exception of the SW region which consisted of streams near Phoenix, Arizona, and Albuquerque, New Mexico, all streams in each region were located within about 100 km of each other (see Supplementary Table 1 for stream names and locations).



Supplementary Figure 2: An example of model structure (black lines = stream network; grey circles = model stream reaches). Stream networks are divided into segments, defined as the length of stream between tributary junctions, and segments are divided into approximately equal length reaches. For each reach, the upstream contributing reaches and the downstream receiving reach were recorded to enable the model to route flow and nitrate through the network. Within each reach, the box-and-arrow diagram represents water and nitrate flux into (upstream and loading) and out of (export and removal) the reach.



Supplementary Figure 3: The Little Tennessee River network used in the stream network model. The stream network contains 785 km of stream length and the catchment area is 821 km^2. Large and small streams as defined in Figure 4 of main text are represented as thick and thin black lines, respectively. The stream network outlet is located at 35^{o}13'08''N and 83^{o}22'32''W.