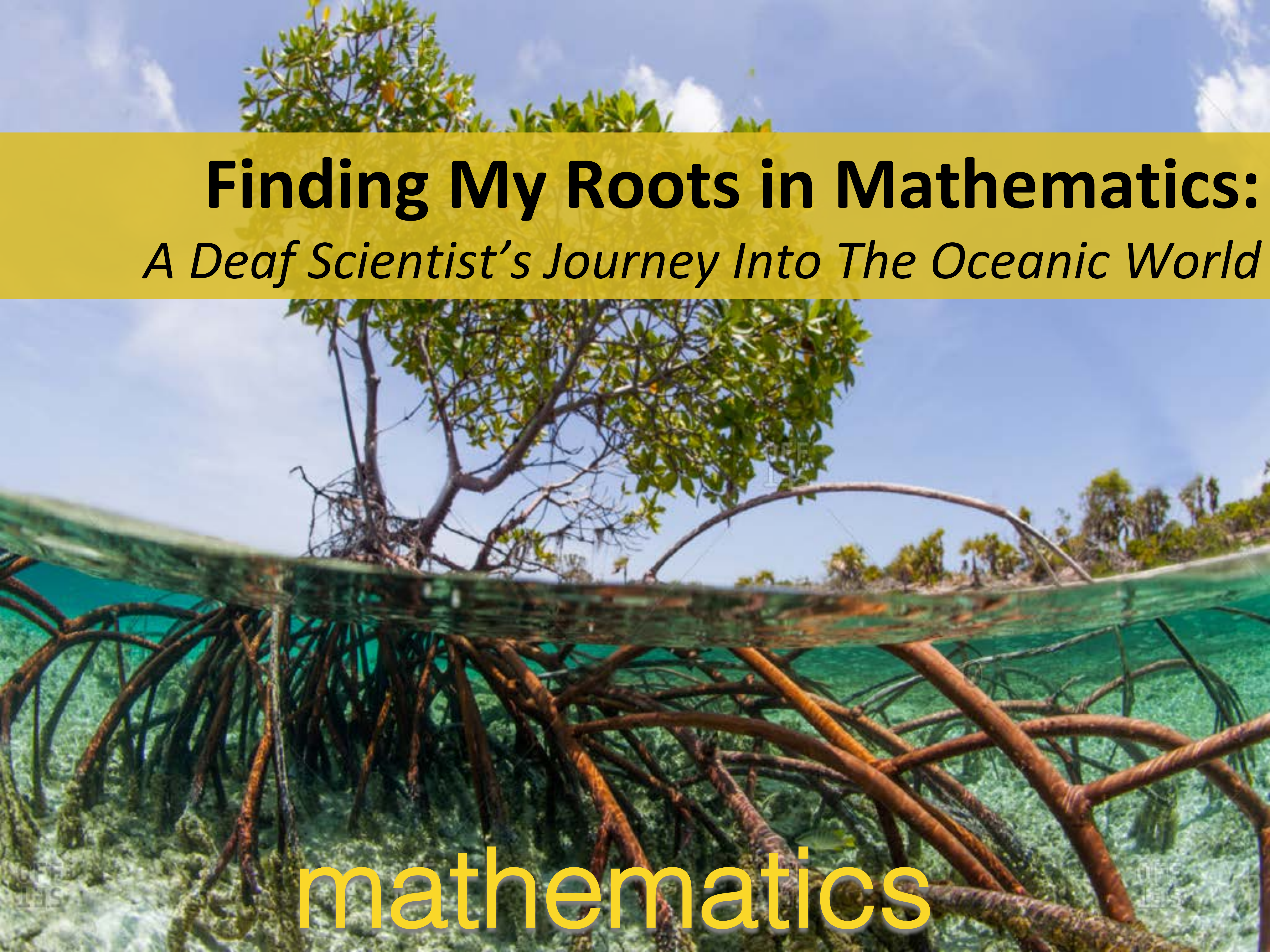
Finding My Roots in Mathematics:

A Deaf Scientist's Journey Into The Oceanic World



ROCHESTER SCHOOL FOR THE DEAF

RSD

Building Futures ...since 1876

RUSH-HENRIETTA

RH

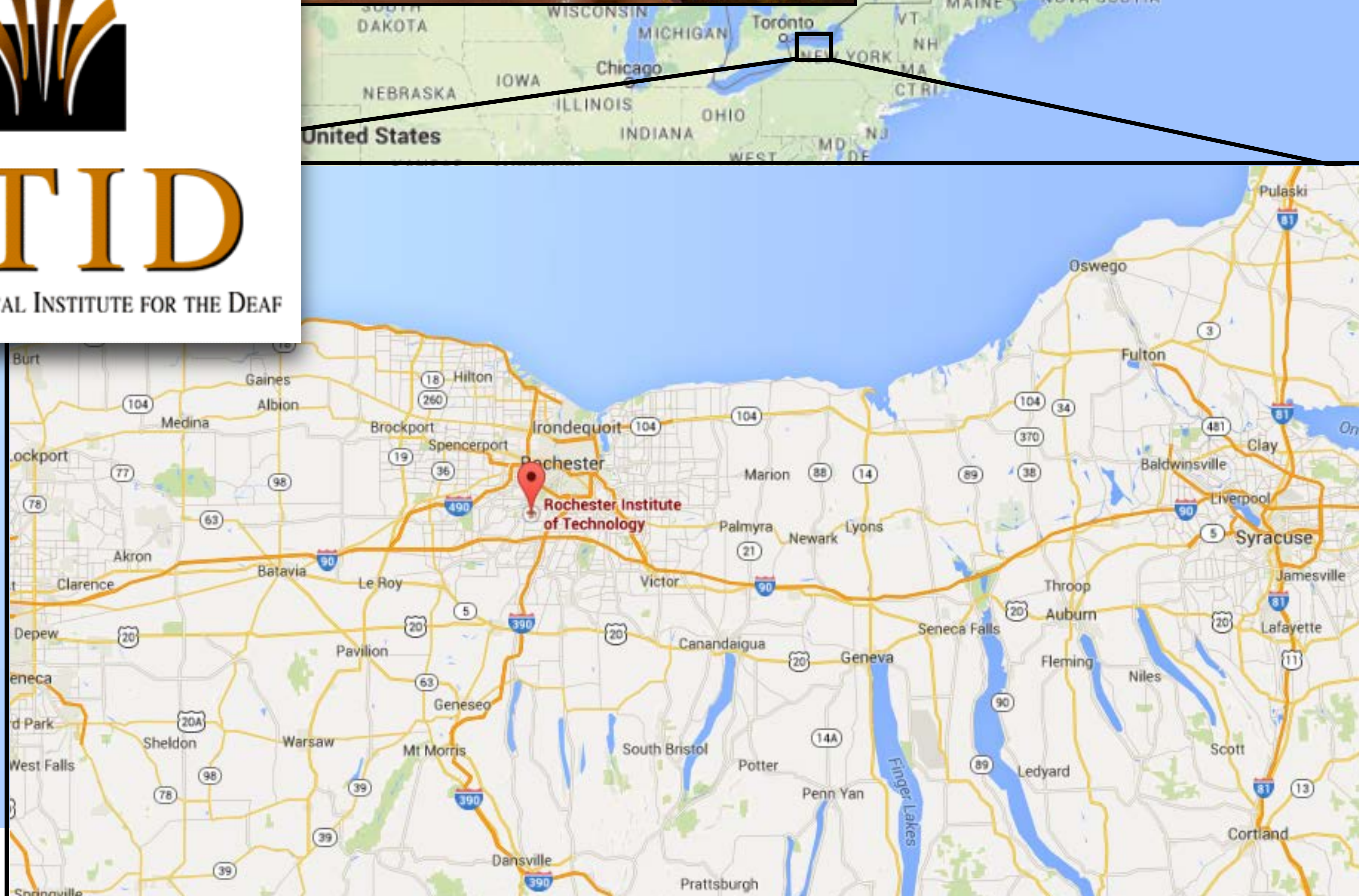
CENTRAL SCHOOL DISTRICT

Guiding Student Success

R·I·T

NTID

NATIONAL TECHNICAL INSTITUTE FOR THE DEAF



Find the derivatives using power rule:

$y = 10x^3$

$y = \frac{1}{2}x^{-2}$

$y = \frac{1}{2\sqrt{x}}$

$y = 3x^{\frac{-1}{15}}$

$y = 8x^6 + 2x^{17}$

$y = \sqrt[5]{x}$

$y = x^{\frac{1}{31}} + x^{\frac{-1}{7}}$

$y = 2x^{12} + 6x^7 + x^4$

$y = \frac{5}{3}x^3 - \frac{7}{6}x^6 + \frac{6}{4}x^8$

$y = \frac{1}{2}x^{\frac{3}{2}} - \frac{22}{7}x^{\frac{-5}{2}} + x^{\frac{3}{7}}$

Ex 1: Starting today a table is being sold at Jaime's furniture store for $345. This is 69% of its regular price. What was the price yesterday?

let x = price yesterday

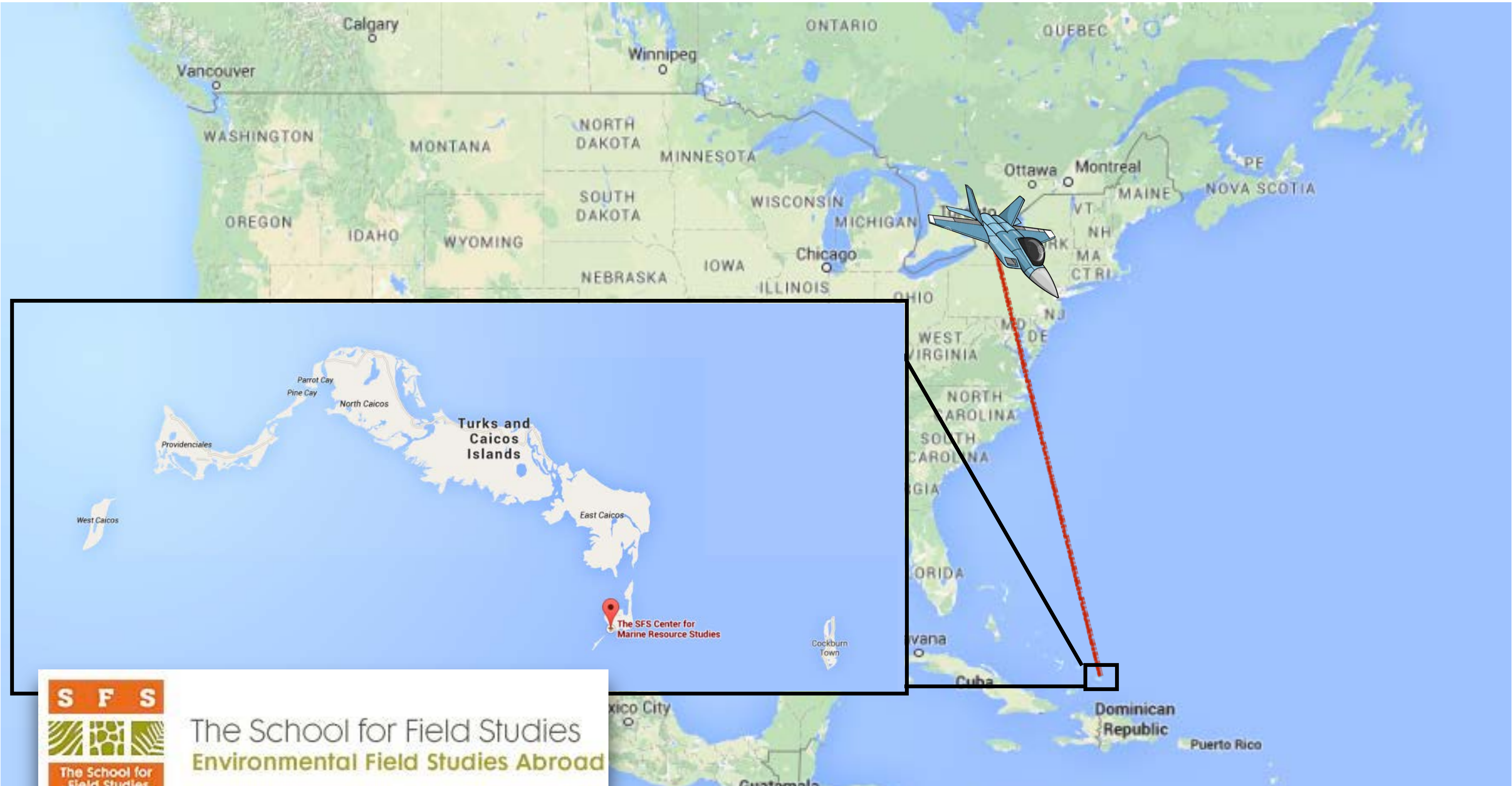
$345 is 69% of x.

$\frac{345}{.69} = \frac{.69x}{.69}$

$x = \frac{345}{.69} = \frac{345}{\frac{69}{100}} = 345$

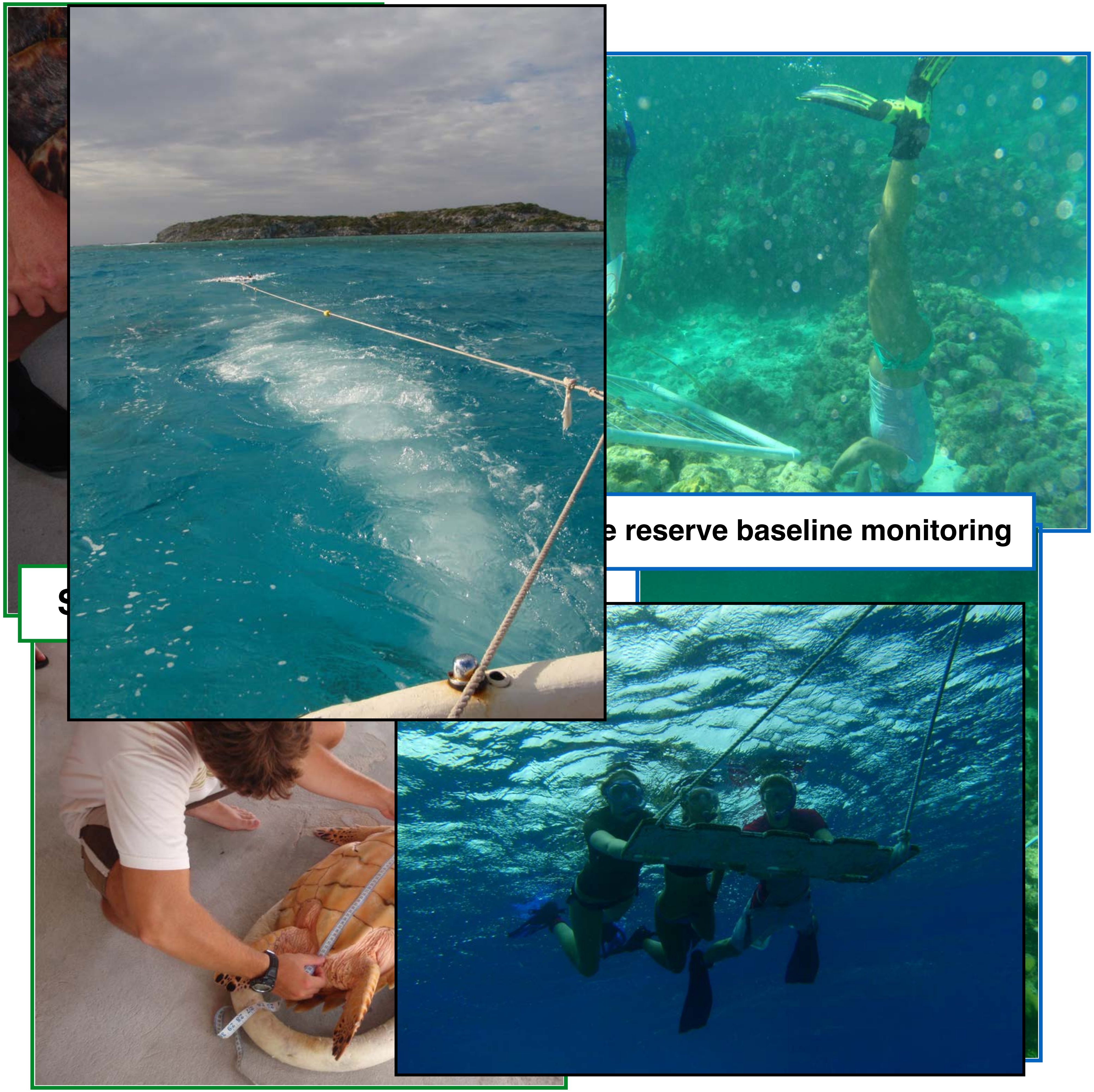
All other teachers

Math teacher



S F S
The School for Field Studies

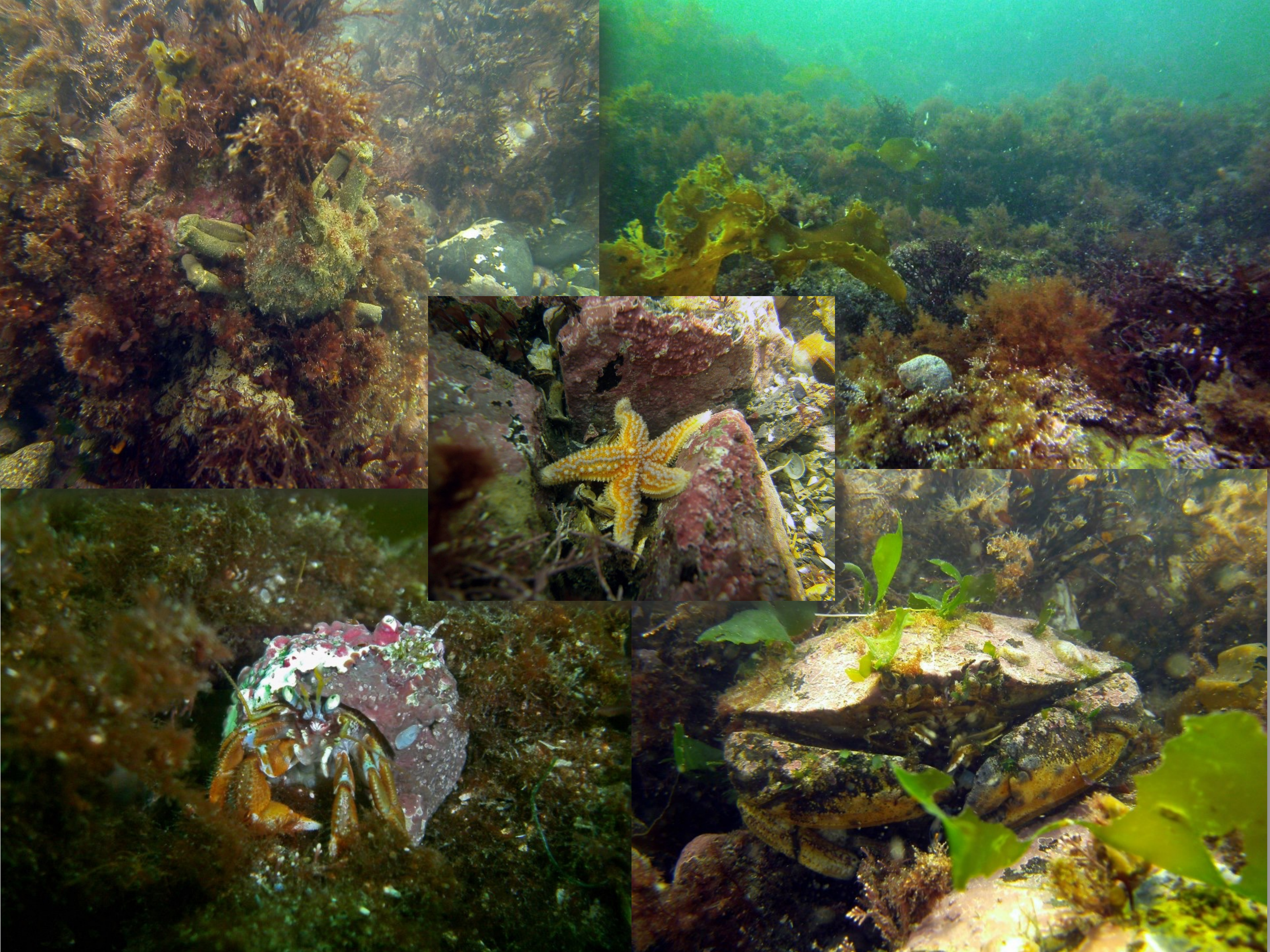
The School for Field Studies
Environmental Field Studies Abroad


e reserve baseline monitoring


Rocky Intertidal
Northeastern University
Northeastern University Marine Science Center
Boston
Cambridge
Somerville
Quincy
Lynn
Nahant
Hull
Winthrop
Revere
Chelsea
Malden
Medford
Newton
Brookline
Waltham
Watertown
Lexington
Arlington
Belmont
Burlington
Woburn
Stoneham
Wakefield
Melrose
Saugus
Marblehead
Cohasset
Milton
Needham
Dedham
Calgary
ONTARIO
QUEBEC
Ottawa
Montreal
Toronto
MAINE
NOVA SCOTIA
NEW YORK
MICHIGAN
OHIO
WEST VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
FLORIDA
Havana
Cuba
Dominican Republic
Puerto Rico
Caribbean Sea
Guatemala
Nicaragua
Costa Rica
Panama
Maracaibo
Caracas
Venezuela

Scientific diving training

Benthic community survey



ECOLOGY O

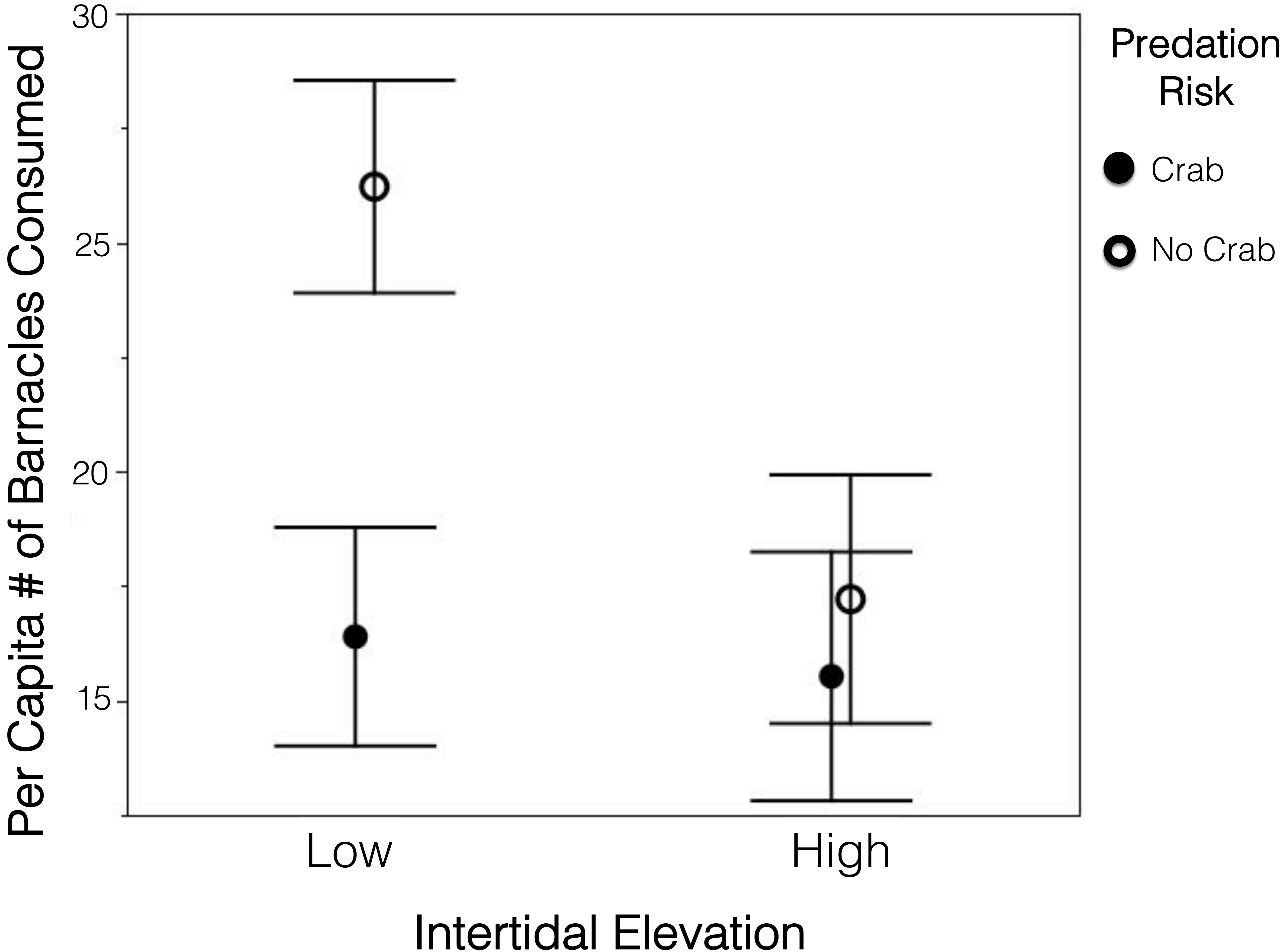
ECOLOGY OF FEAR

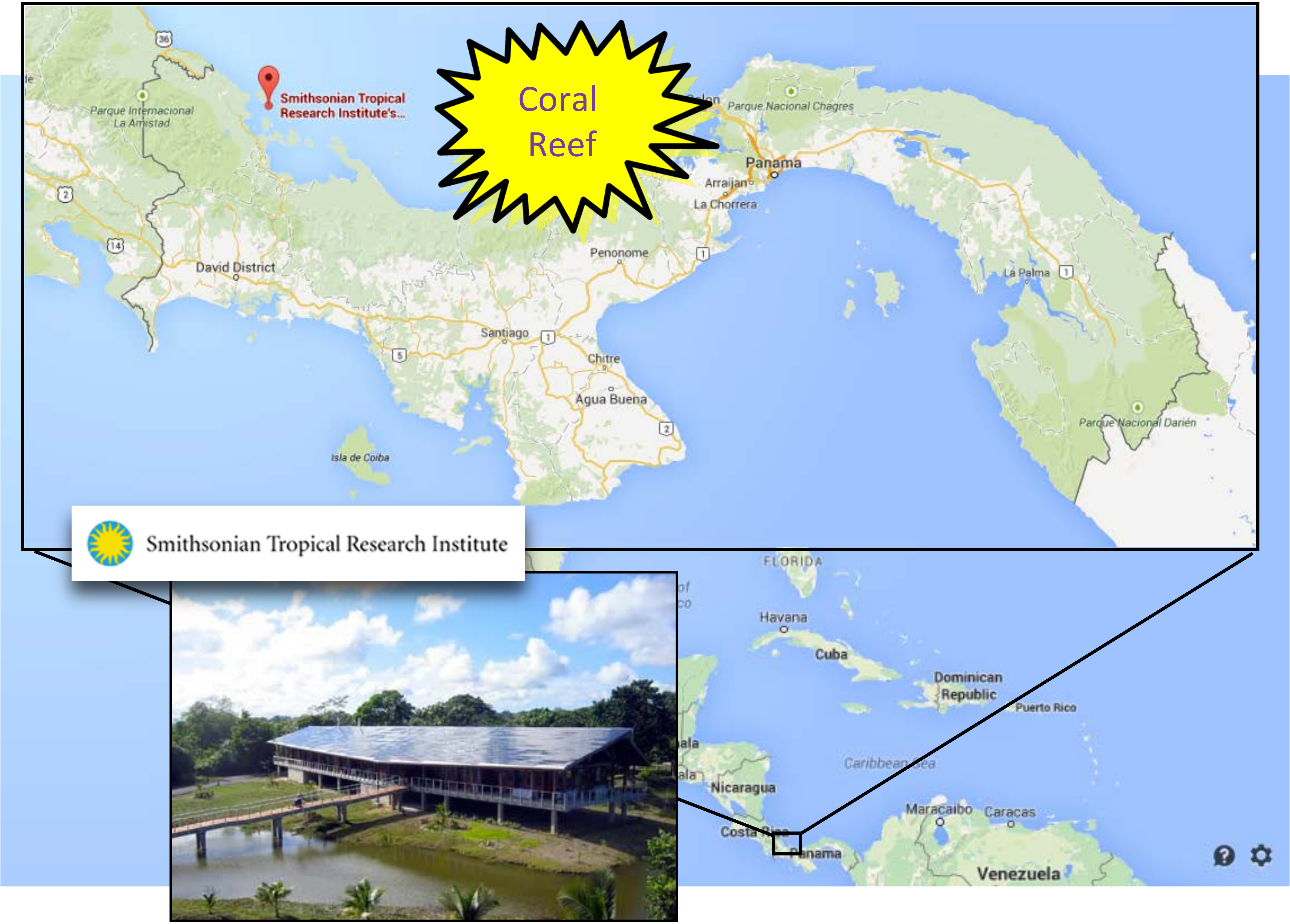
With Cra   No Crab

Initial

Final

Barnacle Cover


30
25
20
15
Per Capita # of Barnacles Consumed
Low
High
Intertidal Elevation
Predation Risk
Crab
No Crab



Coral Reef
Smithsonian Tropical Research Institute's...
Smithsonian Tropical Research Institute
Parque Internacional La Amistad
David District
Santiago
Chitre
Agua Buena
Isla de Coiba
Penonome
Panama
Arraijan
La Chorrera
Parque Nacional Chagres
La Palma
Parque Nacional Darien
FLORIDA
Havana
Cuba
Dominican Republic
Puerto Rico
Caribbean Sea
Nicaragua
Maracaibo
Caracas
Venezuela

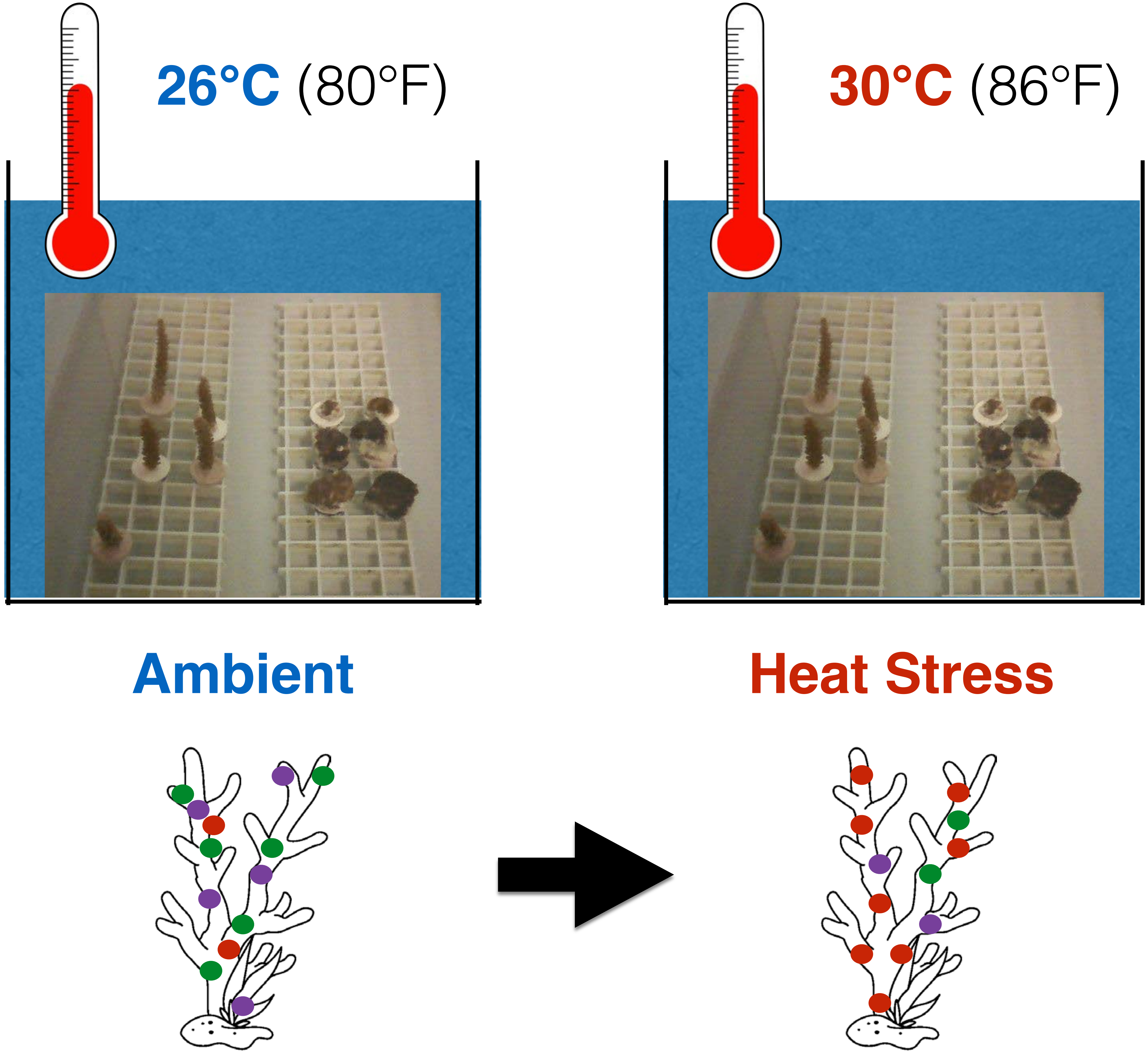

OCEANIC

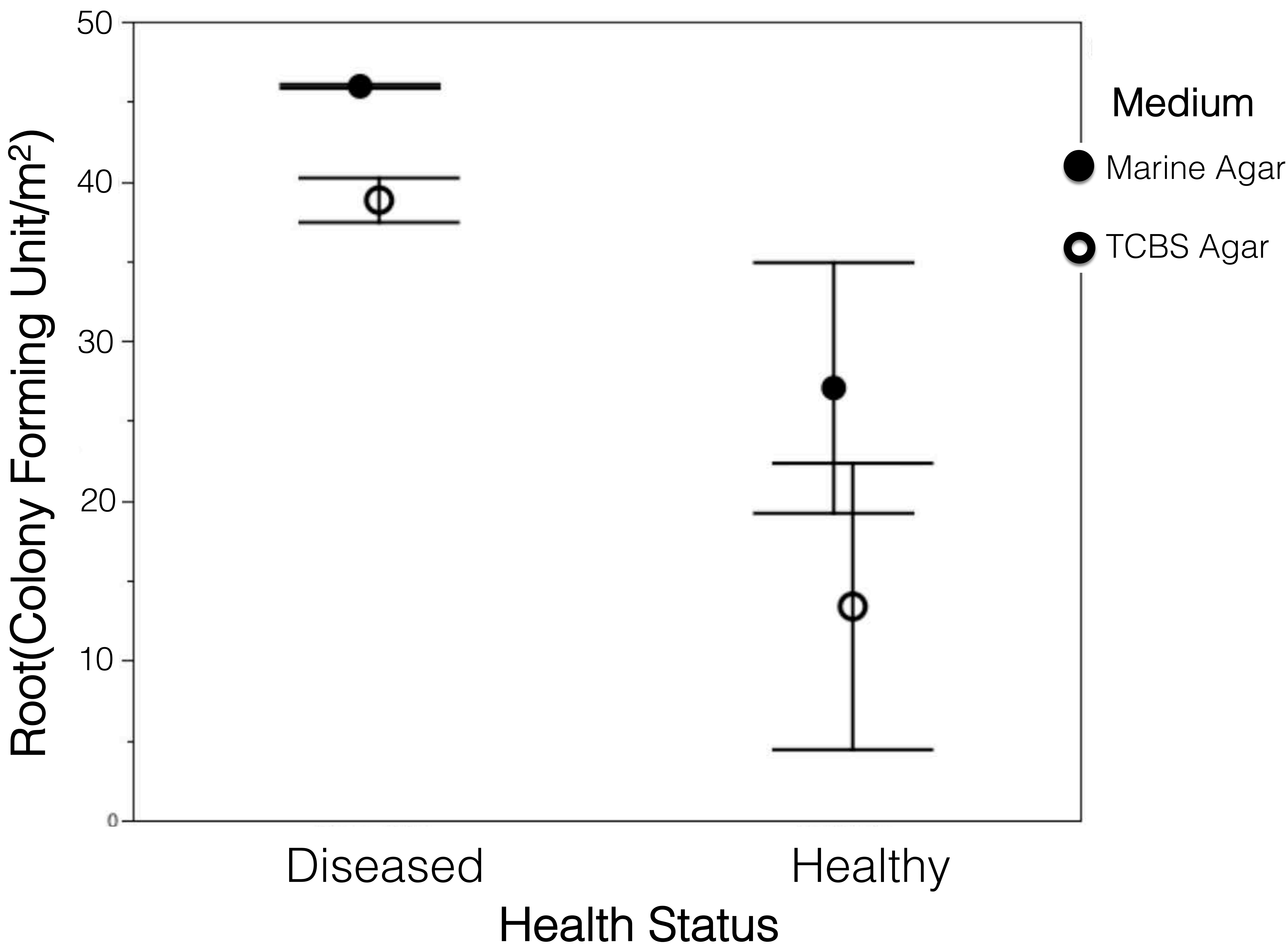
White Band Disease

Microbial community

Disease prevalence

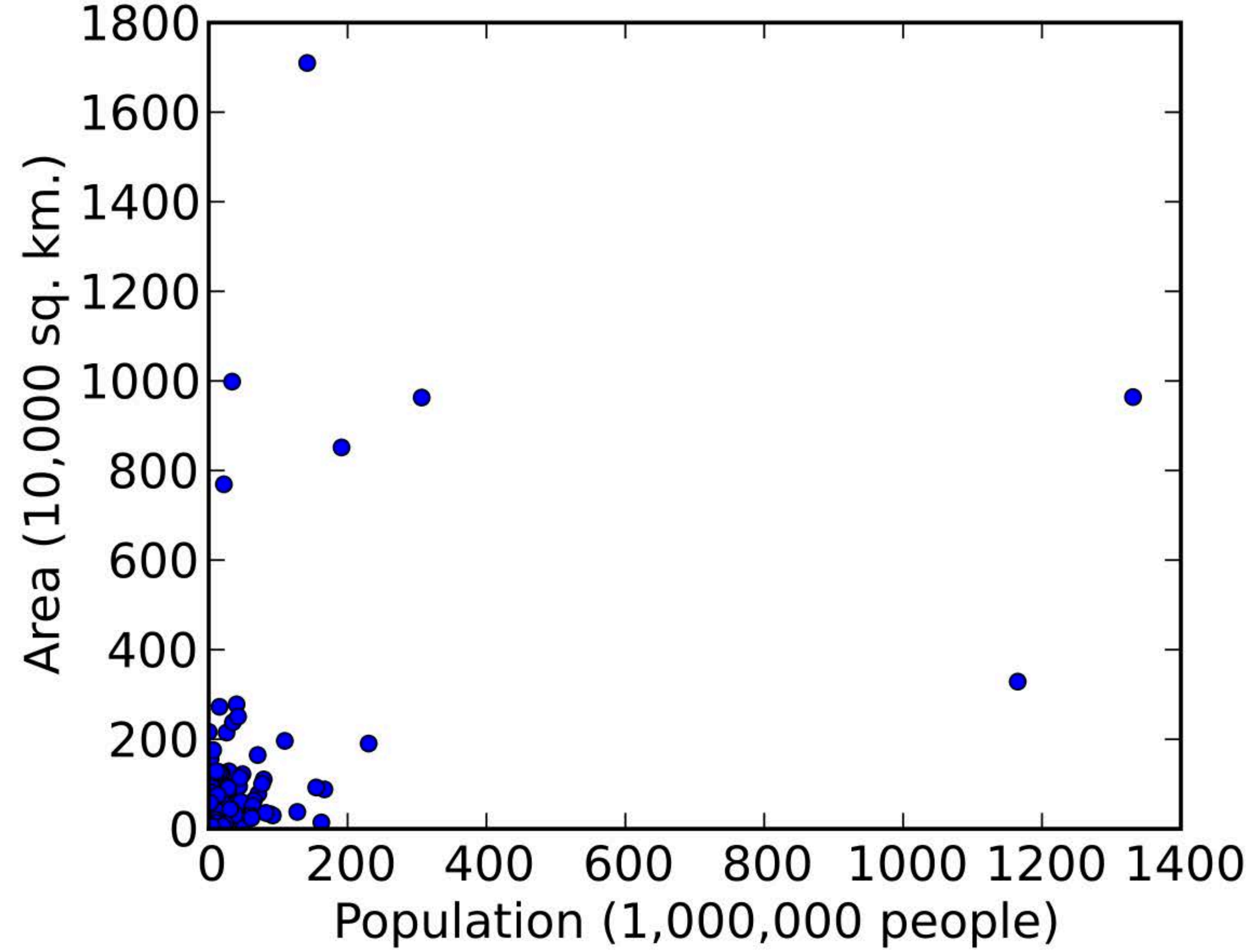
Heat stress

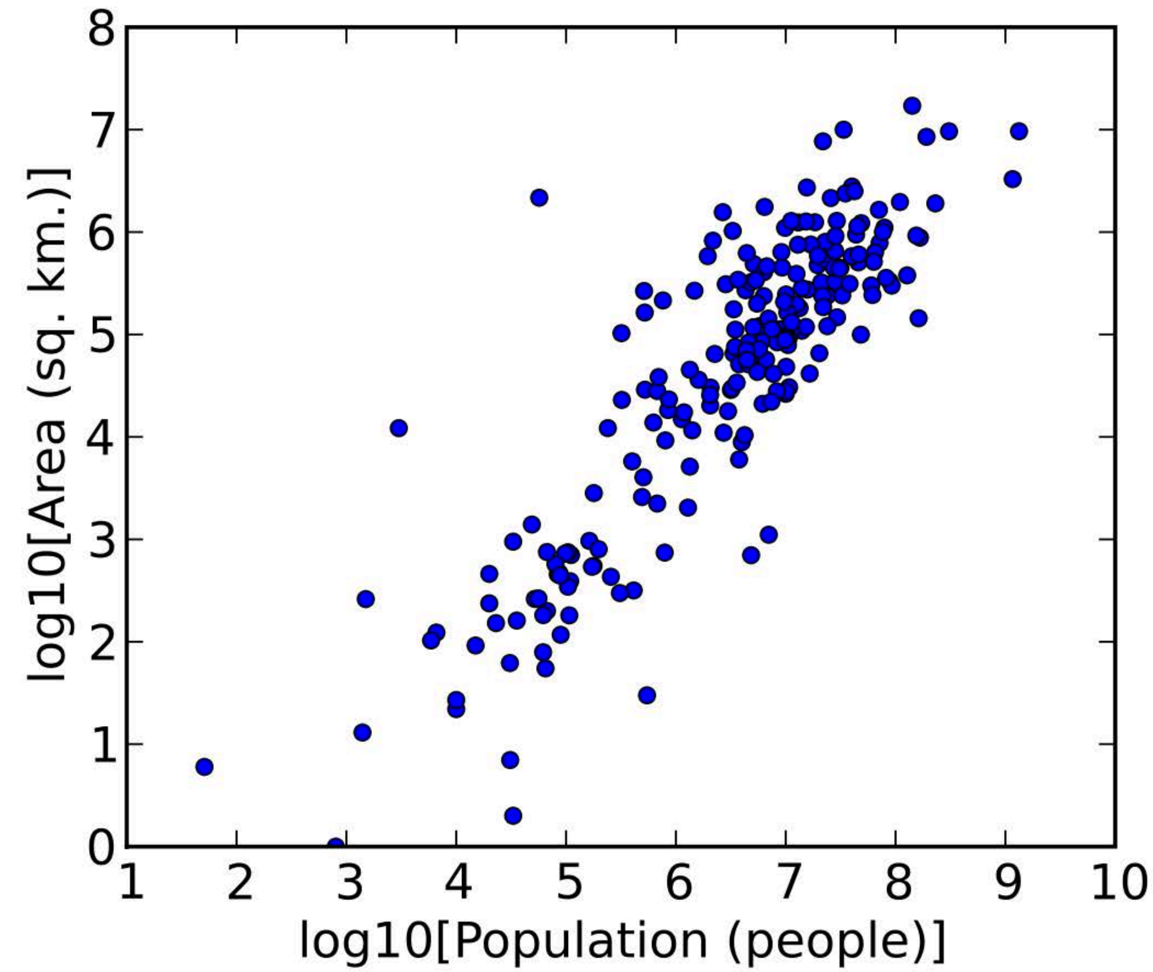

26°C (80°F)
30°C (86°F)
Ambient
Heat Stress



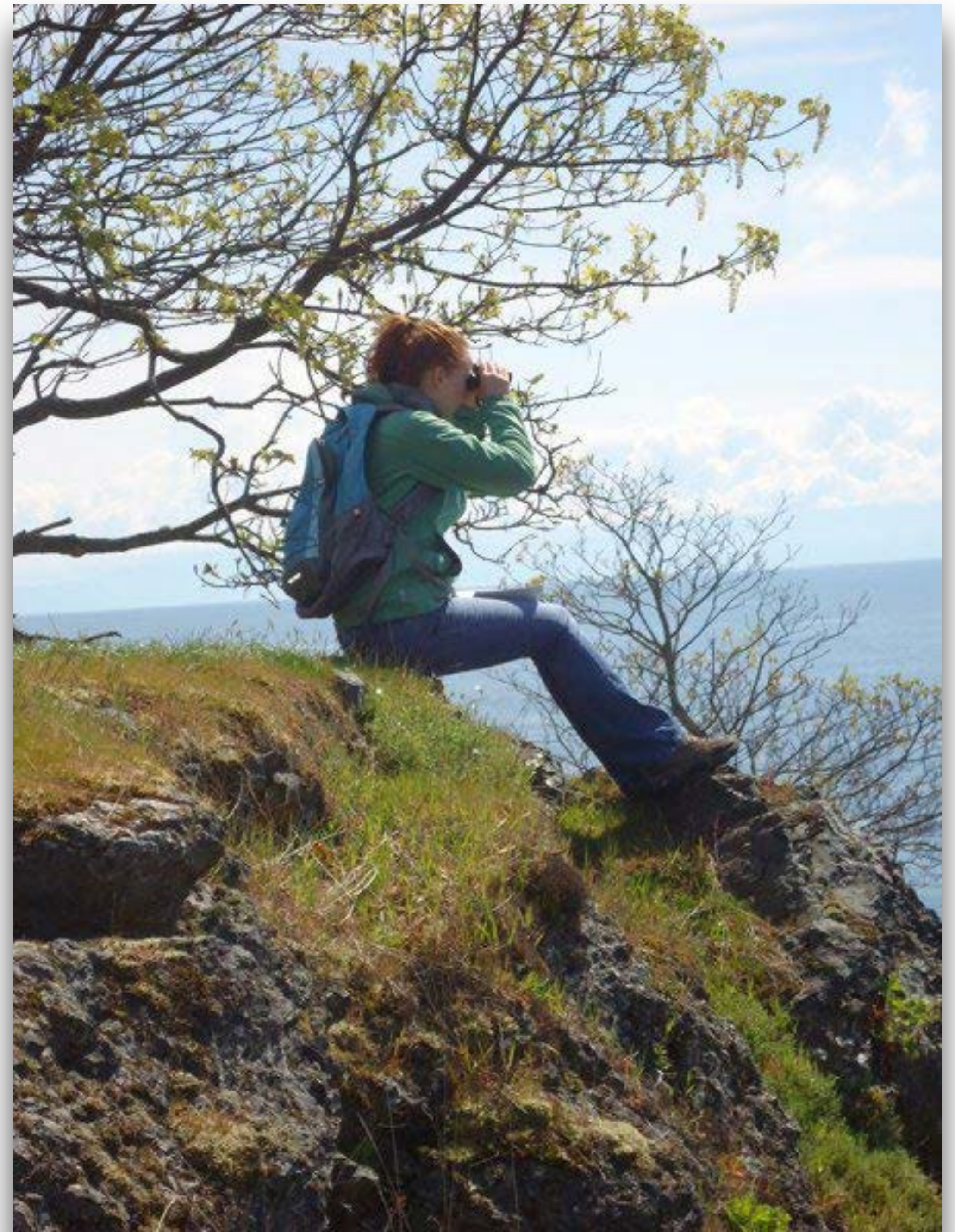
50
40
30
20
10
0
Root(Colony Forming Unit/m²)
Diseased
Healthy
Health Status
Medium
Marine Agar
TCBS Agar

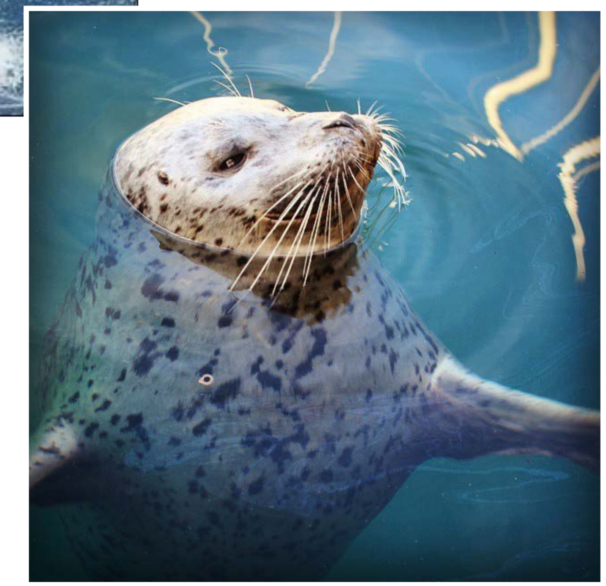
Transformed data allow us to see data clearly and detect patterns





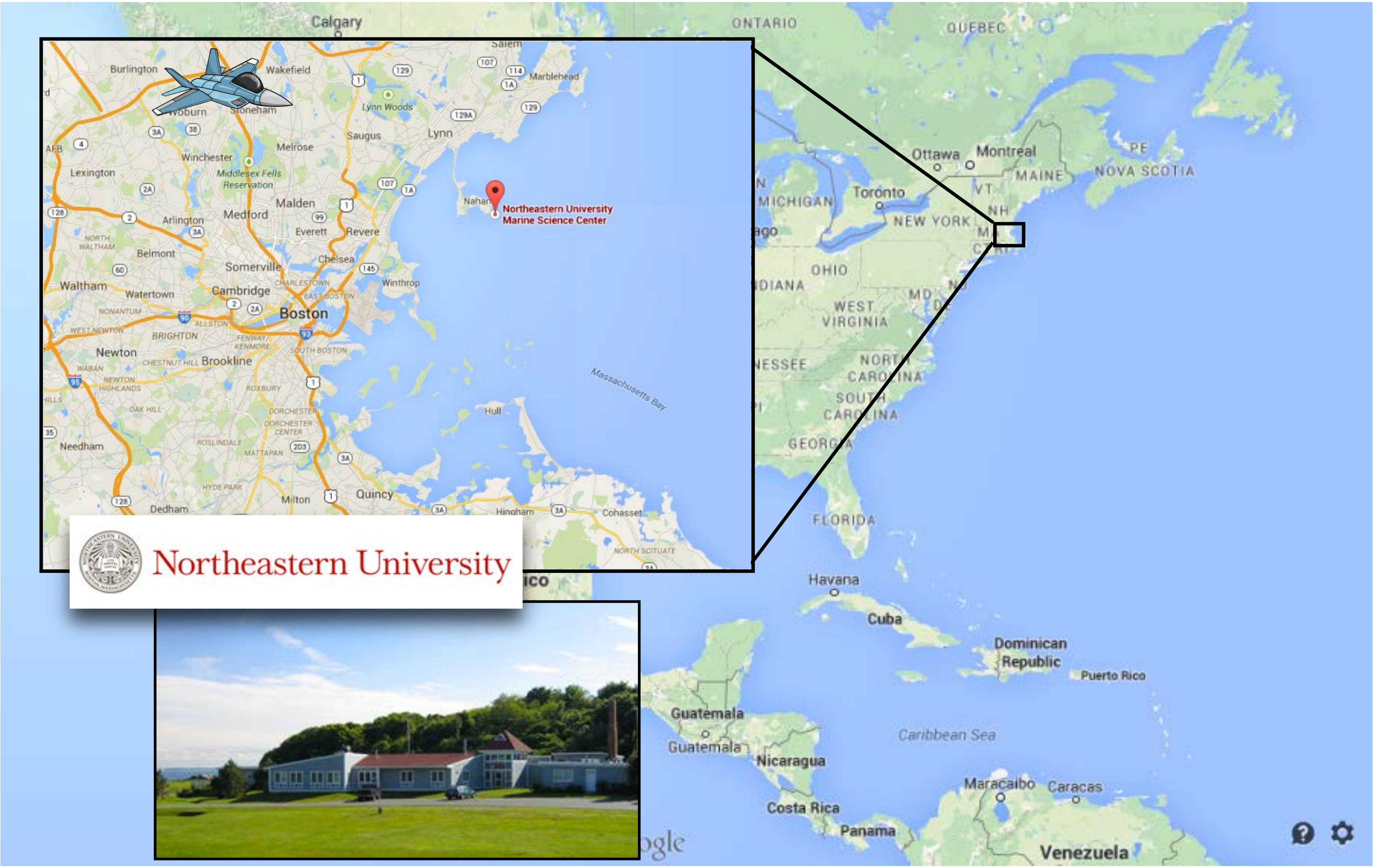

Vancouver
Calgary
WASHINGTON
MONTANA
OREGON
IDAHO
WYOMING
NEVADA
UTAH
CALIFORNIA
Las Vegas
Los Angeles
ARIZONA
NEW MEXIC
Phoenix
San Diego
Gulf of California
Mexico
Guadalajara
Mexico Cit
Puerto Rico
Caracas
Venezuela
Delta
Langley
White Rock
Abbotsford
Ladysmith
Duncan
Bellingham
Sidney
Victoria
University of Washington, Friday...
Mt Vernon
North Cascades National Park
Mt. Baker-Snoqualmie National Forest
Marysville
Whidbey Island
Everett
Lynnwood
Shoreline
Bothell
Redmond
Silverdale
Seattle
Bremerton
Sammamish
Renton
Issaquah
Kent
Rosedale
Auburn
Tacoma
Shelton
Lakewood
Puyallup
Okanogan-Wenatch National Forest
Olympic National Forest
Kelp Forest
UNIVERSITY of WASHINGTON







Northeastern University
Northeastern University Marine Science Center
Nahant
Lynn
Saugus
Lynn Woods
Marblehead
Salem
Wakefield
Burlington
Woburn
Stoneham
Winchester
Melrose
Middlesex Fells Reservation
Lexington
Malden
Medford
Arlington
Everett
Revere
Chelsea
Belmont
Somerville
Charlestown
Winthrop
East Boston
Waltham
Watertown
Cambridge
Boston
Nonantum
Allston
Brighton
West Newton
Fenway/Kenmore
South Boston
Newton
Chestnut Hill
Brookline
Waban
Newton Highlands
Roxbury
Oak Hill
Dorchester
Dorchester Center
Roslindale
Mattapan
Needham
Hyde Park
Milton
Quincy
Dedham
Hull
Hingham
Cohasset
North Scituate
Massachusetts Bay
Calgary
ONTARIO
QUEBEC
Ottawa
Montreal
MAINE
VT
NH
NOVA SCOTIA
PE
Toronto
MICHIGAN
NEW YORK
OHIO
WEST VIRGINIA
MD
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
FLORIDA
Havana
Cuba
Dominican Republic
Puerto Rico
Guatemala
Nicaragua
Costa Rica
Panama
Caribbean Sea
Maracaibo
Caracas
Venezuela

Ecological Applications, 26(1), 2016, pp. 264–278

Reciprocal feedbacks between spatial subsidies and reserve networks in coral reef meta-ecosystems

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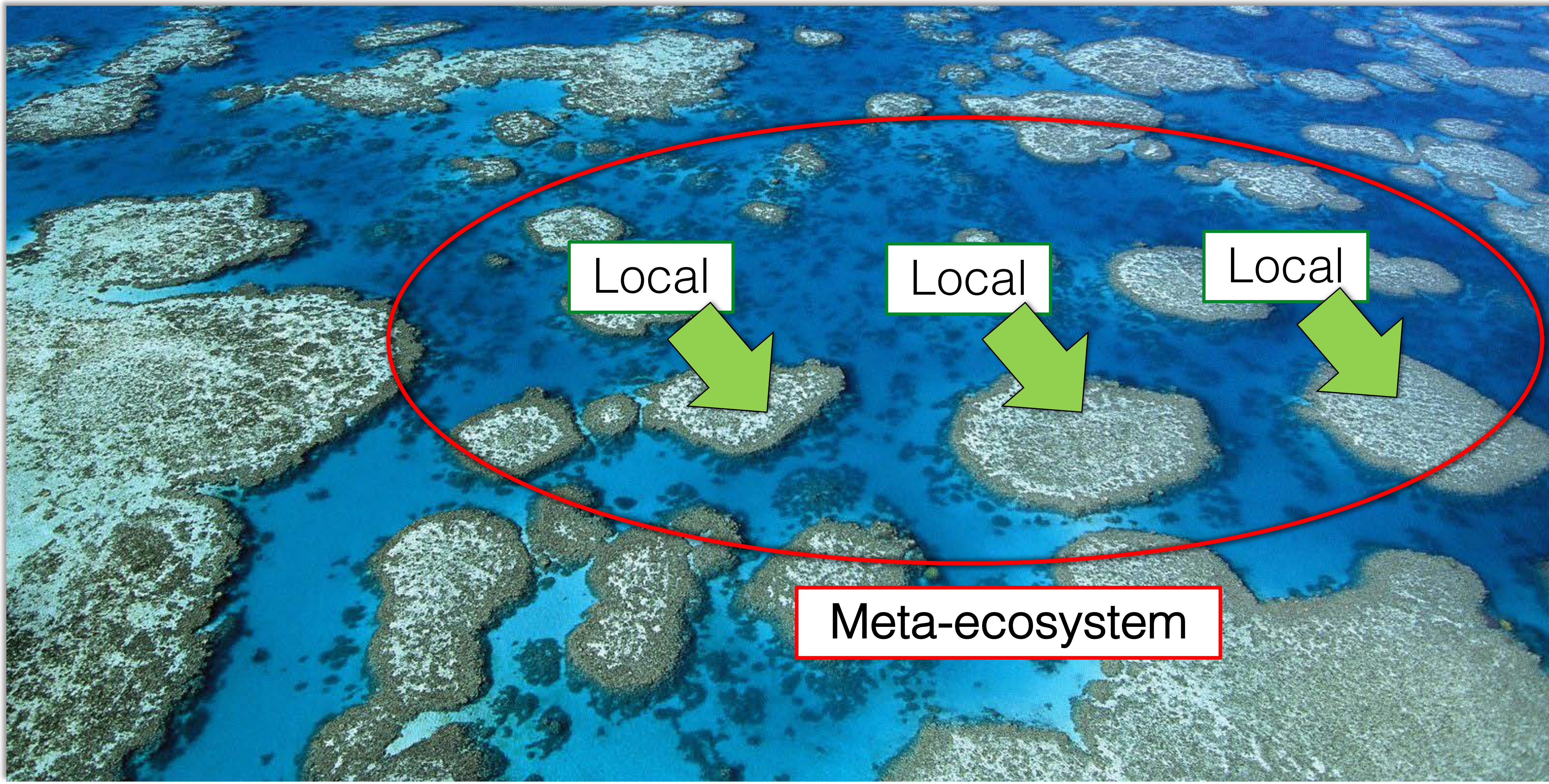
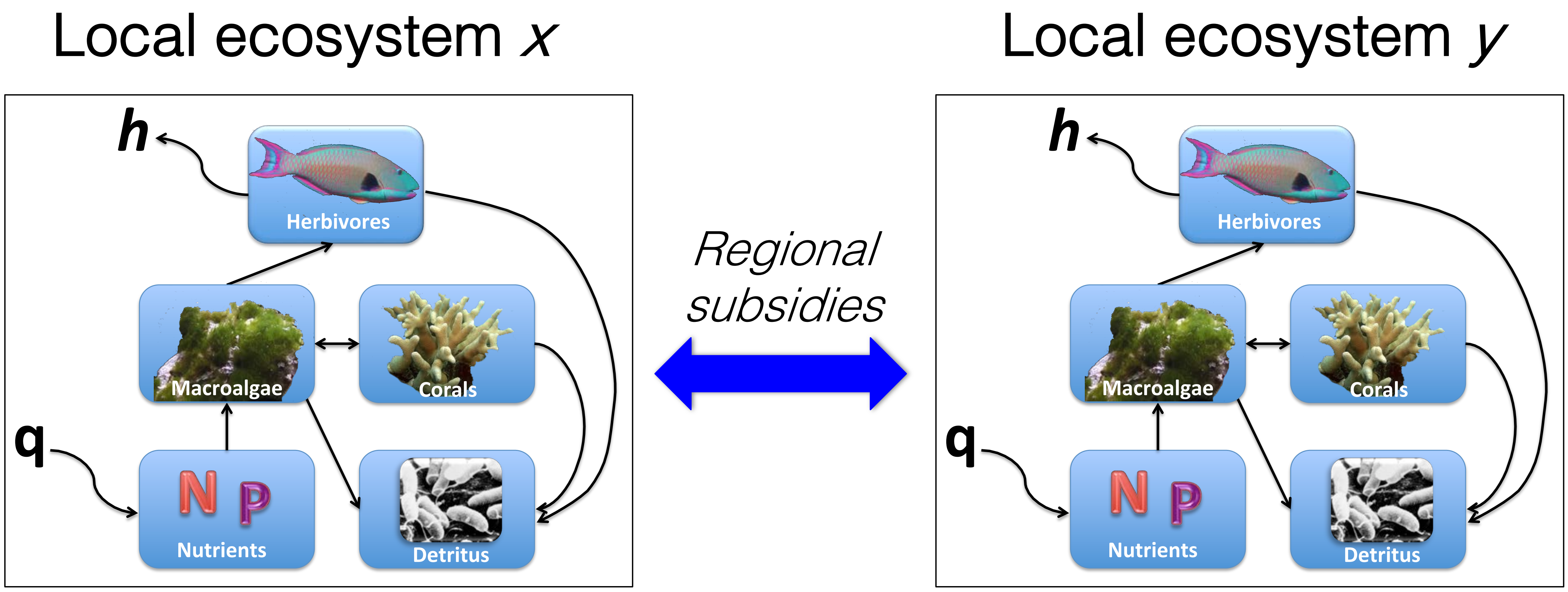
[2]*Department of Biology, McGill University, 1205 Avenue Docteur Penfield, Montréal, Québec, H3A1B1, Canada*

Abstract. Top-down processes such as predation and herbivory have been shown to control the dynamics of communities across a range of ecosystems by generating trophic cascades. However, theory is only beginning to describe how these local trophic processes interact with spatial subsidies in the form of material (nutrient, detritus) transport and organismal dispersal to (1) shape the structure of interconnected (meta-) ecosystems and (2) determine their optimal management via reserve networks. Here, we develop a meta-ecosystem model to understand how the reciprocal feedbacks between spatial subsidies and reserve networks modulate the importance of top-down control in a simple herbivorous fish–macroalgae–coral system. We show that in large and isolated reserve networks where connectivity between protected and unprotected areas is limited, spatial subsidies remain largely confined to reserves. This retention of spatial subsidies promotes the top-down control of corals and macroalgae by herbivores inside reserves but reduces it outside reserves. Conversely, in small and aggregated reserves where connectivity between protected and unprotected areas is high, the spillover of spatial subsidies causes a reduction in top-down control of corals and macroalgae by herbivores inside reserves and an increase in the strength of top-down control outside reserves. In addition, we demonstrate that there is a trade-off between local and regional conservation objectives when designing reserve networks: small and aggregated reserves based on the extent of dispersal maximize the abundance of corals and herbivores regionally, whereas large and isolated reserves always maximize the abundance of corals within reserves, regardless of the extent of dispersal. The existence of such "conservation traps," which arise from the fulfillment of population-level objectives within local reserves at the cost of community-level objectives at regional scales, suggests the importance of adopting a more holistic strategy to manage complex and interconnected ecosystems.

Key words: corals; dispersal; material transport; meta-ecosystem; reserve networks; spatial management; spatial subsidies; top-down control; trophic cascades


Local
Local
Local
Meta-ecosystem

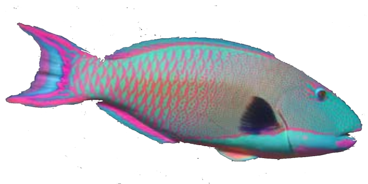


Local ecosystem x
Local ecosystem y
h
q
Herbivores
Macroalgae
Corals
Nutrients
Detritus
N P
Regional subsidies

Modeling local and regional dynamics using integro-differential equations

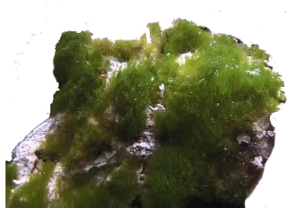
Regional process

Local process



$$\frac{\mathrm{d}H(x)}{\mathrm{d}t} = \frac{aM(x)H(x)}{1 + avM(x)} - m_H H(x) - h(x)H(x) - d_H H(x) + \int_{-\frac{L}{2}}^{\frac{L}{2}} d_H(y)\kappa_H(x-y)\,\mathrm{d}y$$

$$\frac{\mathrm{d}C(x)}{\mathrm{d}t} = \left[\int_{-\frac{L}{2}}^{\frac{L}{2}} r_C C(y)\kappa_C(x-y)\mathrm{d}y\right](1 - M(x) - C(x)) - m_C C(x)$$



$$\frac{\mathrm{d}M(x)}{\mathrm{d}t} = \left[\int_{-\frac{L}{2}}^{\frac{L}{2}} \frac{r_M N(y)}{1 + kN(y)} M(y)\kappa_M(x-y)\mathrm{d}y\right](1 - M(x) - C(x)) - m_M M(x) - \frac{aM(x)H(x)}{1 + avM(x)}$$

$$\frac{\mathrm{d}D(x)}{\mathrm{d}t} = m_M M(x) + m_H H(x) + m_C C(x) - \gamma D(x) - d_D D(x) + \int_{-\frac{L}{2}}^{\frac{L}{2}} d_D(y)\kappa_D(x-y)\,\mathrm{d}y$$

N P

$$\frac{\mathrm{d}N(x)}{\mathrm{d}t} = q - \epsilon N(x) + f\gamma D(x) - \frac{r_M N(x)}{1 + kN(x)} M(x) - d_N N(x) + \int_{-\frac{L}{2}}^{\frac{L}{2}} d_N(y)\kappa_N(x-y)\mathrm{d}y$$

Editor – /Users/barbaraspiecker/Documents/Academia/Research/NU Research/MATLAB/metaecosystem_analysis/determine_local_stability_met...

place_reserves.m | run_place_reserves.m | determine_local_stability_metaecosystem_1D.m

```
function [equi, abundS, abundM1, abundN1, abundC, abundM2, abundN2, mapVals] = ...
    determine_local_stability_metaecosystem_1D (rSval, mSval, rMval, mMval, rCval, mCval, betaval, q1val, q2val, eps1val, eps2v
global S C M1 M2 N1 N2 eps1 eps2 rM rC rS q1 q2 mM mC mS d beta;
syms S C M1 M2 N1 N2 gam eps1 eps2 rM rC rS q1 q2 mM mC mS d beta;
model=[rS*S*(1-S-M1)-mS*S; ...
    rM*N1*M1*(1-S-M1)-mM*M1; ...
    d*(eps2*N2-eps1*N1)+q1-eps1*N1-rM*M1*N1; ...
    rC*C*(1-C-M2)-mC*C; ...
    rM*N2*M2*(1-C-M2)-mM*M2-beta*M2; ...
    d*(eps1*N1-eps2*N2)+q2-eps2*N2-rM*M2*N2];
sol=solve(model, S, M1, N1, C, M2, N2);

% Number of solutions
nsol=length(sol.C);

% Jacobian matrix used to compute local stability
v=[S, M1, N1, C, M2, N2];
jacGenericTemplate=jacobian(model, v);

mapVals=nan(length(betaval),1);
abundS=nan(length(betaval),1);
abundM1=nan(length(betaval),1);
abundN1=nan(length(betaval),1);
abundC=nan(length(betaval),1);
abundM2=nan(length(betaval),1);
abundN2=nan(length(betaval),1);

% Equilibrium states
equi.DensSUnstable=nan(nsol, length(betaval));
equi.DensM1Unstable=nan(nsol, length(betaval));
equi.DensN1Unstable=nan(nsol, length(betaval));
```

Large, isolated reserve

<u>outside</u> reserve

<u>inside</u> reserve

Small, aggregated reserves

New England Aquarium

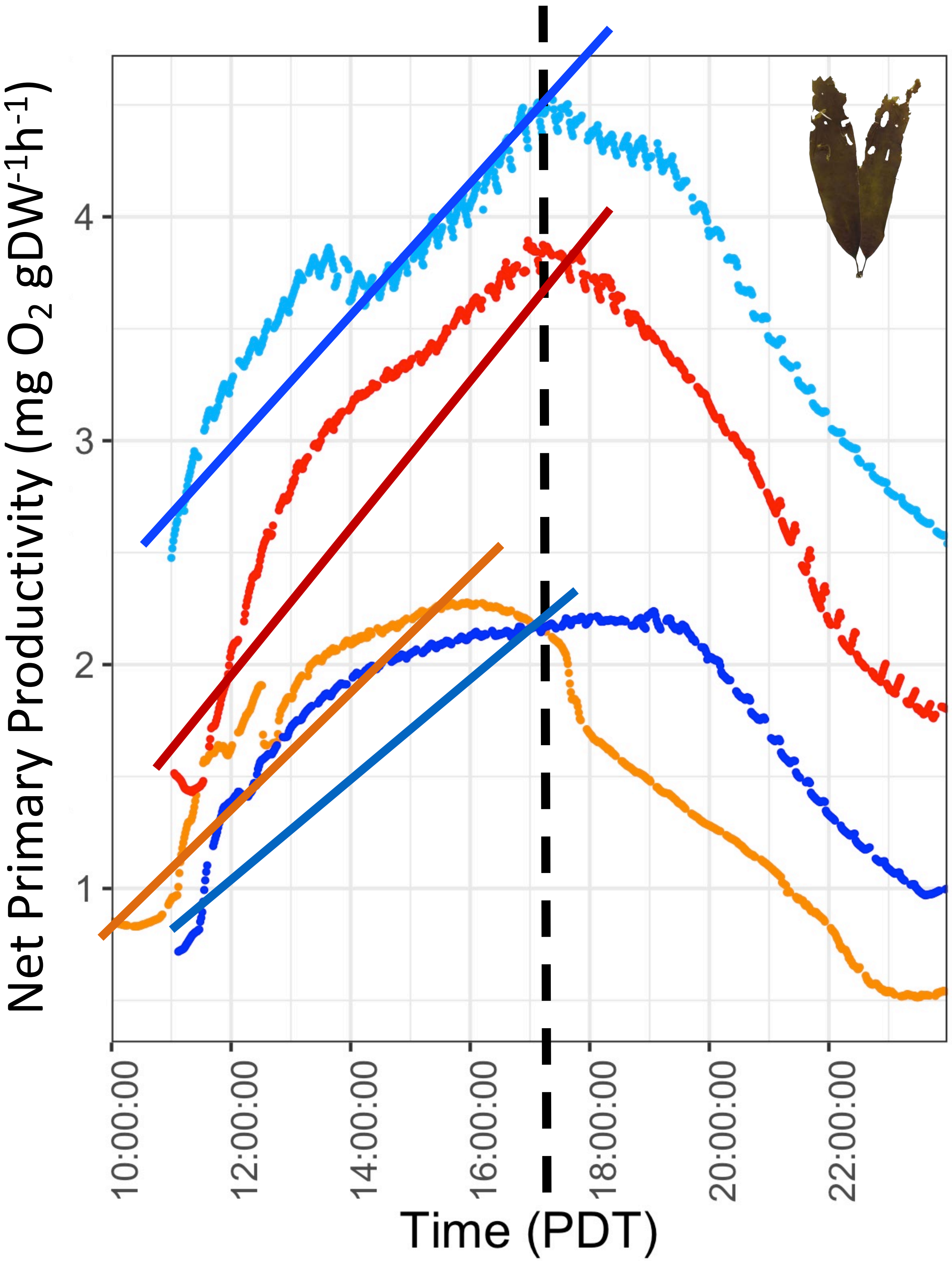




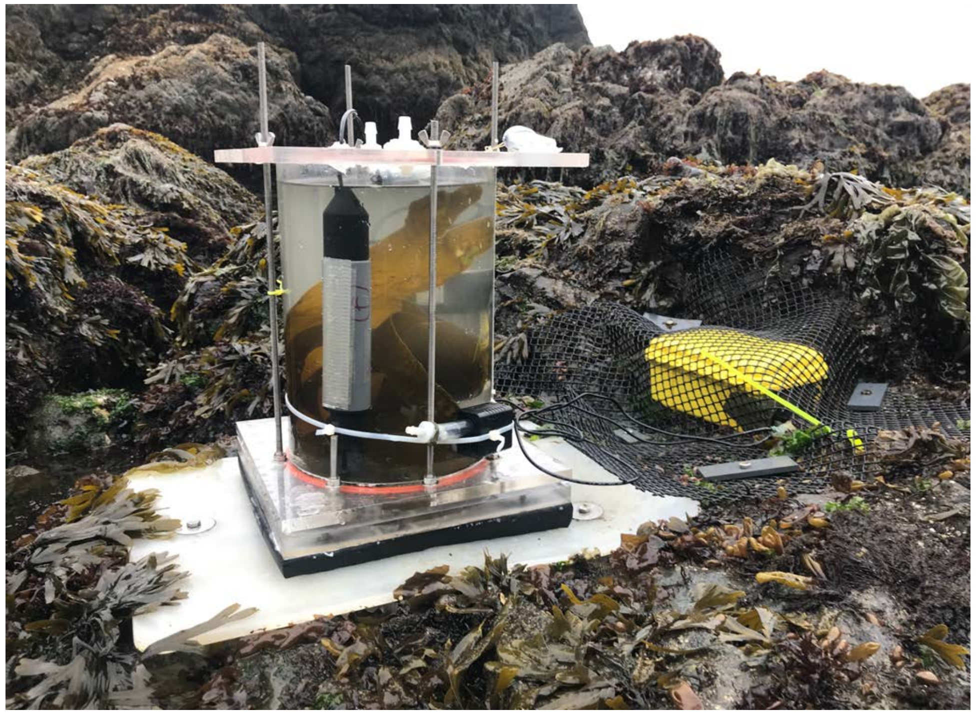
Calgary
Vancouver
WASHINGTON
MONTANA
OREGON
IDAHO
WYOMING
NEVADA
UTAH
CALIFORNIA
Las Vegas
Los Angeles
ARIZONA
NEW MEXIC
Phoenix
San Diego
Gulf of California
Monterrey
Mexico
Guadalajara
Mexico Ci
FLORIDA
Gulf of Mexico
Costa Rica
Panama
Venezuela
Google
National Forest
Clatsop State Forest
St Helens
Vancouver
Portland
Hillsboro
Gresham
Beaverton
Tualatin
Oregon City
The Dalles
Tillamook State Forest
Mt Hood National Forest
McMinnville
Salem
Dallas
Oregon State University
Public school
known for research
Siuslaw National Forest
Eugene
Spring
Oregon State
UNIVERSITY
OSU

When you are in the water and seaweed touches your leg

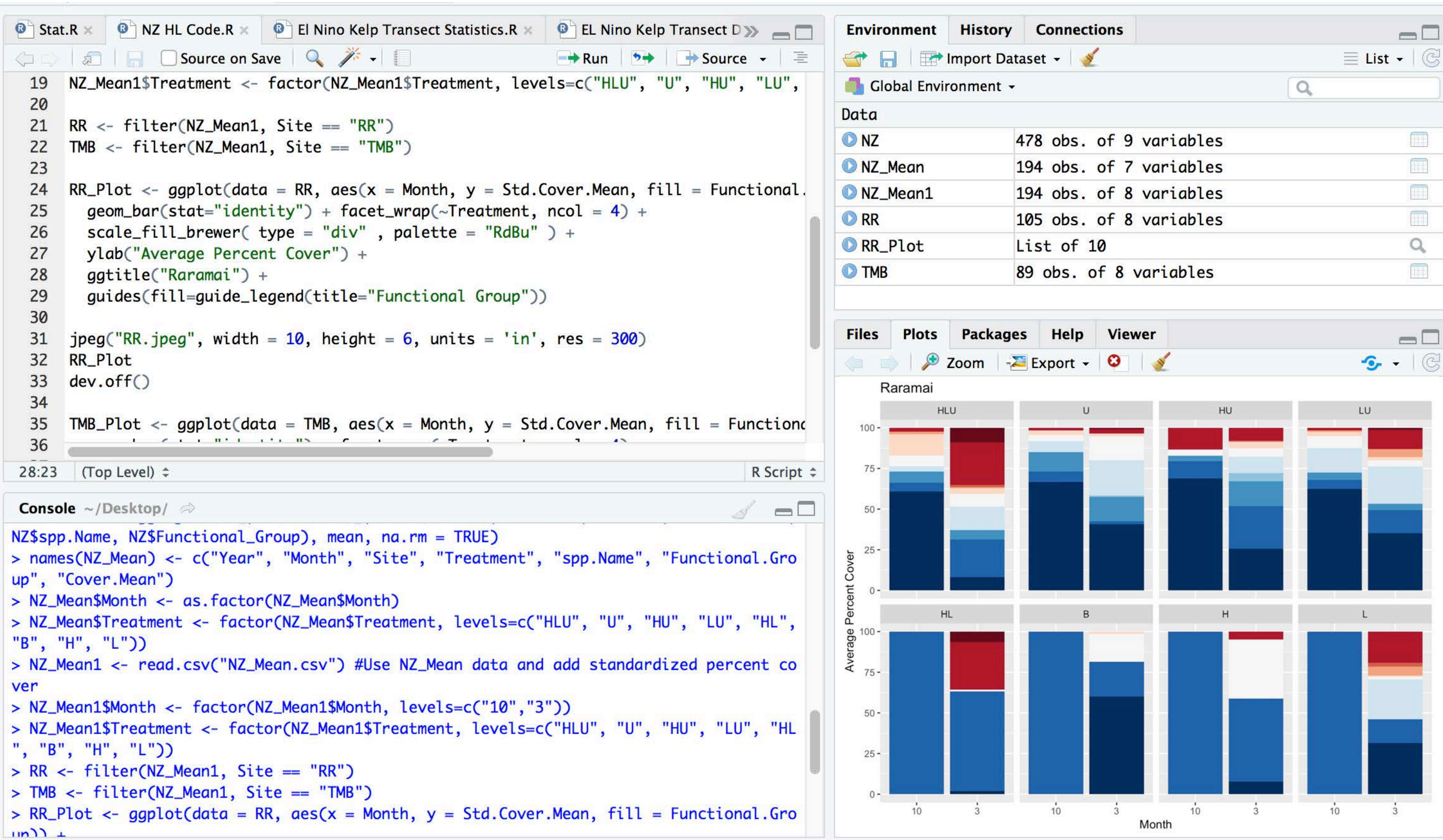

OSU
ALASKAN
BREWING CO.



Net Primary Productivity (mg O_2 gDW^{-1}h^{-1})
4
3
2
1
10:00:00
12:00:00
14:00:00
16:00:00
18:00:00
20:00:00
22:00:00
Time (PDT)

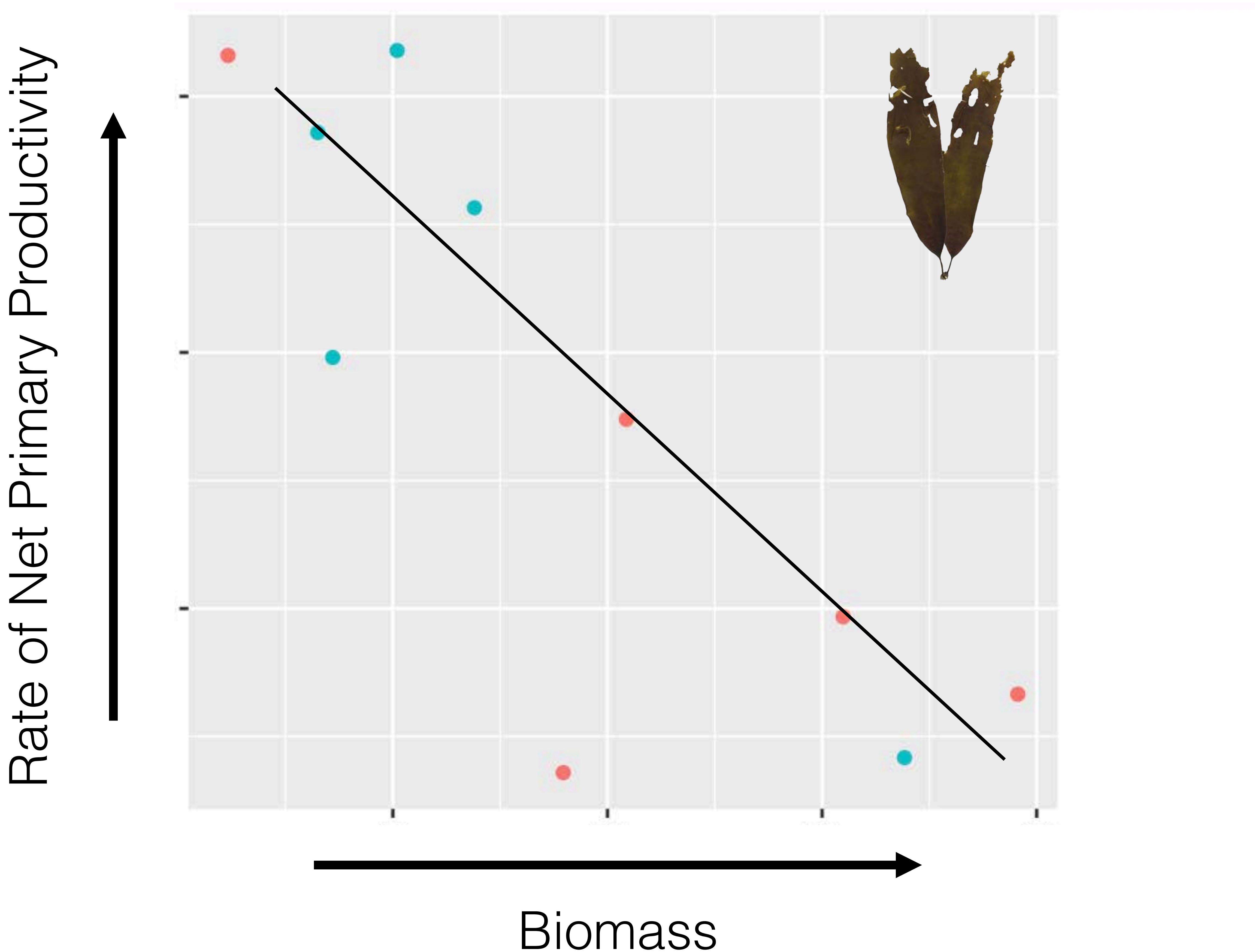


Studio



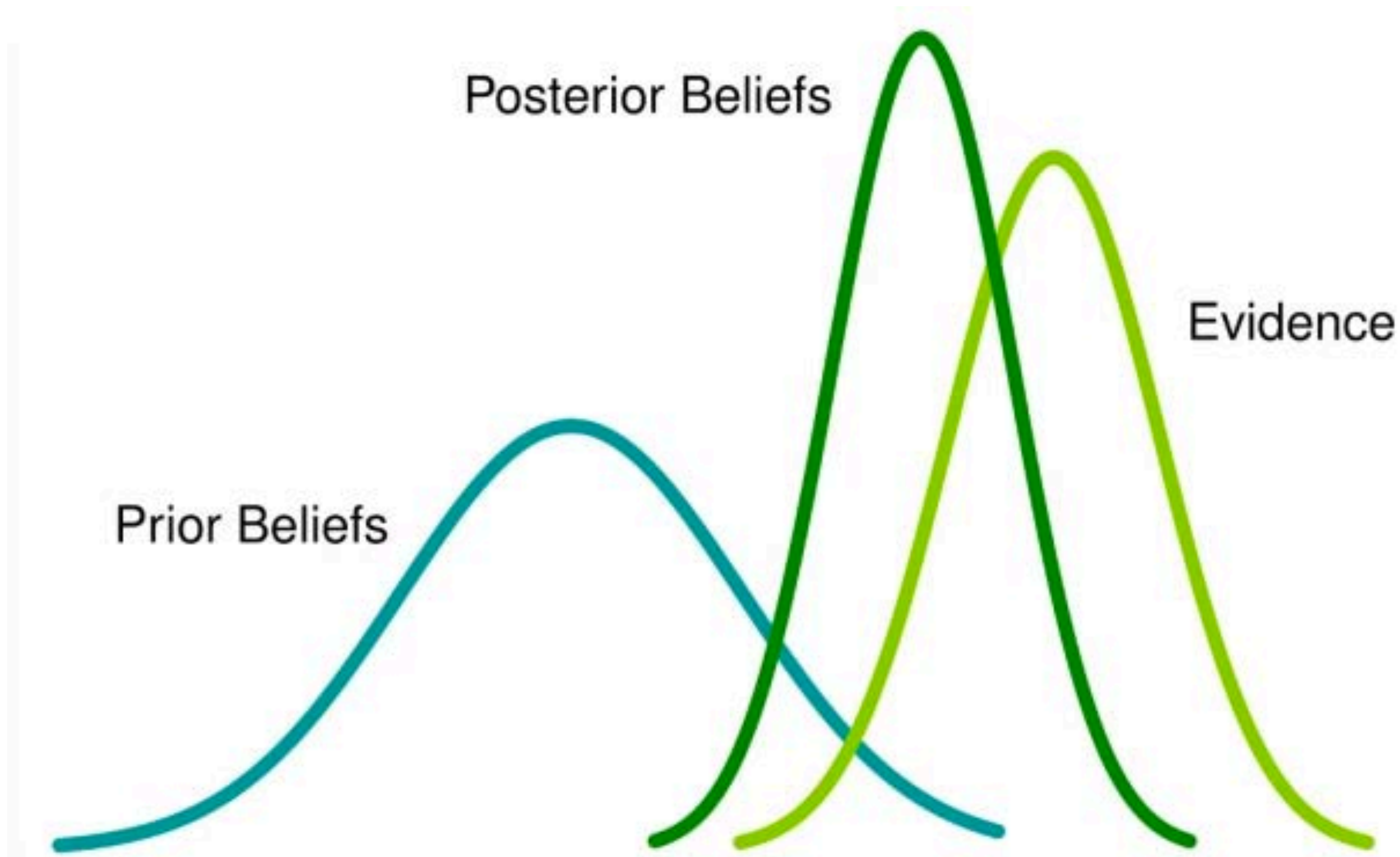
Stat.R
NZ HL Code.R
El Nino Kelp Transect Statistics.R
EL Nino Kelp Transect D
Source on Save
Run
Source
NZ_Mean1$Treatment <- factor(NZ_Mean1$Treatment, levels=c("HLU", "U", "HU", "LU",
RR <- filter(NZ_Mean1, Site == "RR")
TMB <- filter(NZ_Mean1, Site == "TMB")
RR_Plot <- ggplot(data = RR, aes(x = Month, y = Std.Cover.Mean, fill = Functional.
geom_bar(stat="identity") + facet_wrap(~Treatment, ncol = 4) +
scale_fill_brewer(type = "div" , palette = "RdBu") +
ylab("Average Percent Cover") +
ggtitle("Raramai") +
guides(fill=guide_legend(title="Functional Group"))
jpeg("RR.jpeg", width = 10, height = 6, units = 'in', res = 300)
RR_Plot
dev.off()
TMB_Plot <- ggplot(data = TMB, aes(x = Month, y = Std.Cover.Mean, fill = Functiona
28:23
(Top Level)
R Script
Console ~/Desktop/
NZ$spp.Name, NZ$Functional_Group), mean, na.rm = TRUE)
> names(NZ_Mean) <- c("Year", "Month", "Site", "Treatment", "spp.Name", "Functional.Group", "Cover.Mean")
> NZ_Mean$Month <- as.factor(NZ_Mean$Month)
> NZ_Mean$Treatment <- factor(NZ_Mean$Treatment, levels=c("HLU", "U", "HU", "LU", "HL", "B", "H", "L"))
> NZ_Mean1 <- read.csv("NZ_Mean.csv") #Use NZ_Mean data and add standardized percent cover
> NZ_Mean1$Month <- factor(NZ_Mean1$Month, levels=c("10","3"))
> NZ_Mean1$Treatment <- factor(NZ_Mean1$Treatment, levels=c("HLU", "U", "HU", "LU", "HL", "B", "H", "L"))
> RR <- filter(NZ_Mean1, Site == "RR")
> TMB <- filter(NZ_Mean1, Site == "TMB")
> RR_Plot <- ggplot(data = RR, aes(x = Month, y = Std.Cover.Mean, fill = Functional.Group)) +
Environment
History
Connections
Import Dataset
List
Global Environment
Data
NZ 478 obs. of 9 variables
NZ_Mean 194 obs. of 7 variables
NZ_Mean1 194 obs. of 8 variables
RR 105 obs. of 8 variables
RR_Plot List of 10
TMB 89 obs. of 8 variables
Files
Plots
Packages
Help
Viewer
Zoom
Export
Raramai
Average Percent Cover
Month

Size-dependent photosynthesis rate



Bayesian analyses to answer the burning question:

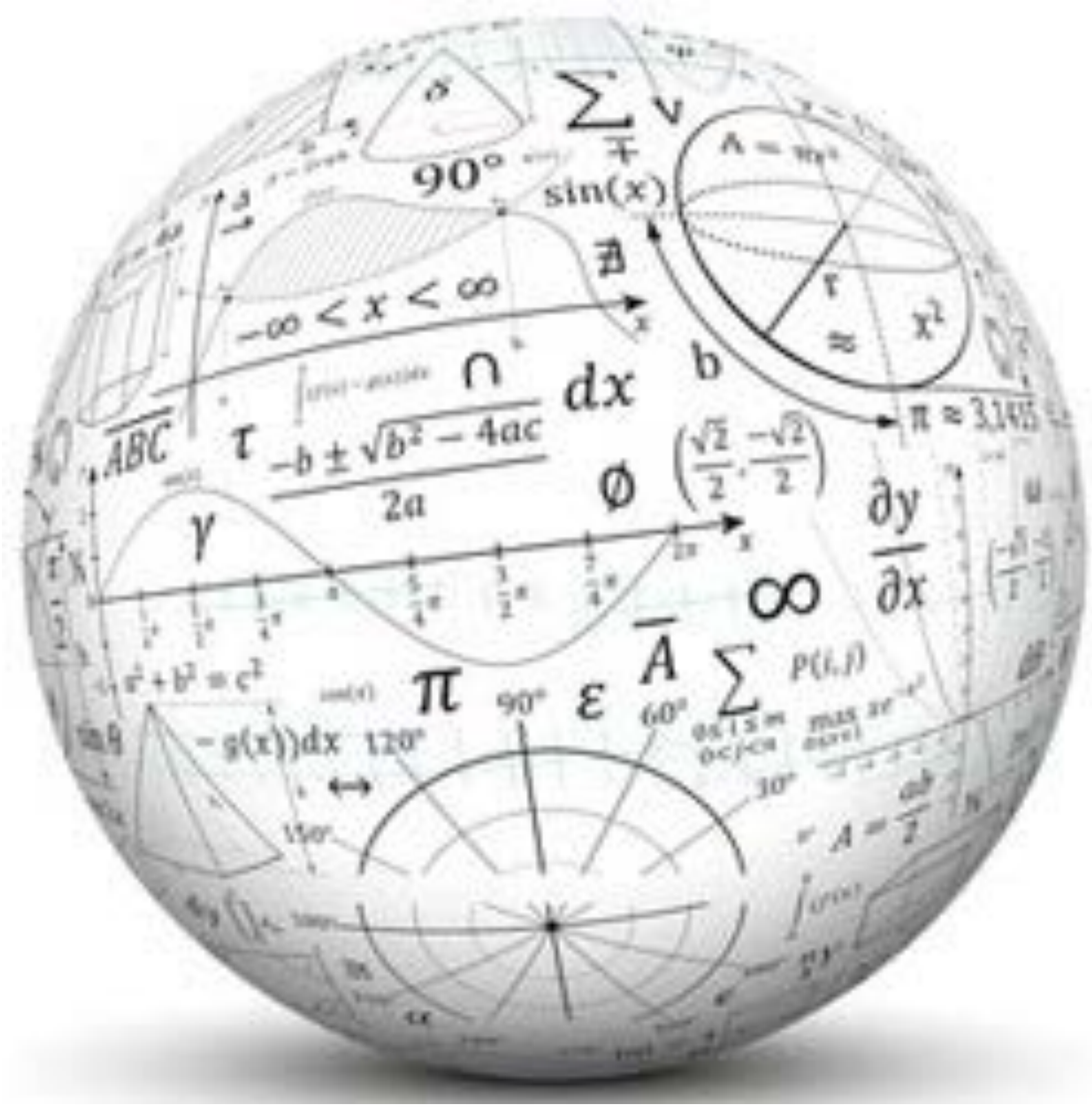
Can we use our past as a predictor for our future?



Using **math** to define our natural world

Mathematical modeling allows us to:

- Remove logistical constraints
- Identify uncertainties
- Detect patterns



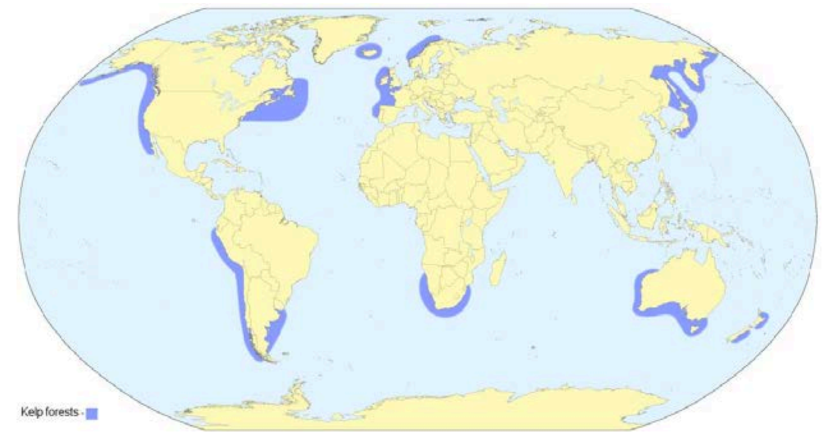

POST DOC

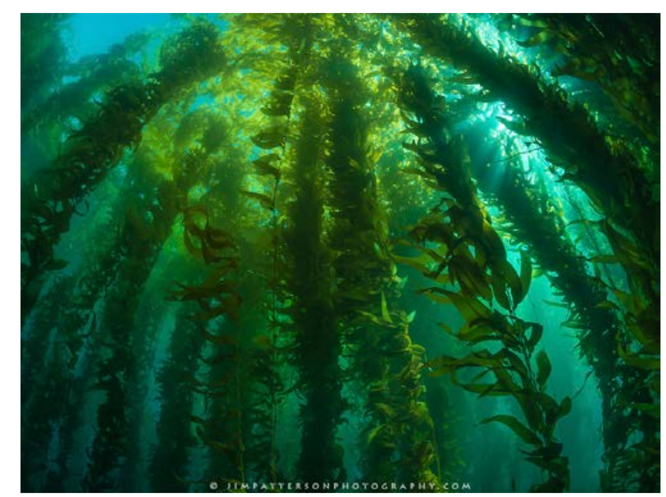
POST DOC

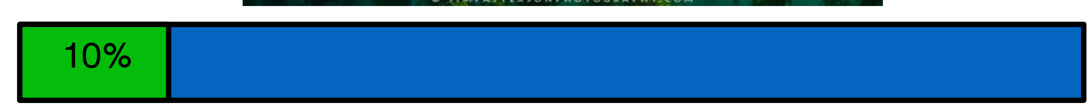
Kelp Forests

HABITAT AND BREEDING GROUNDS

FOOD SOURCE

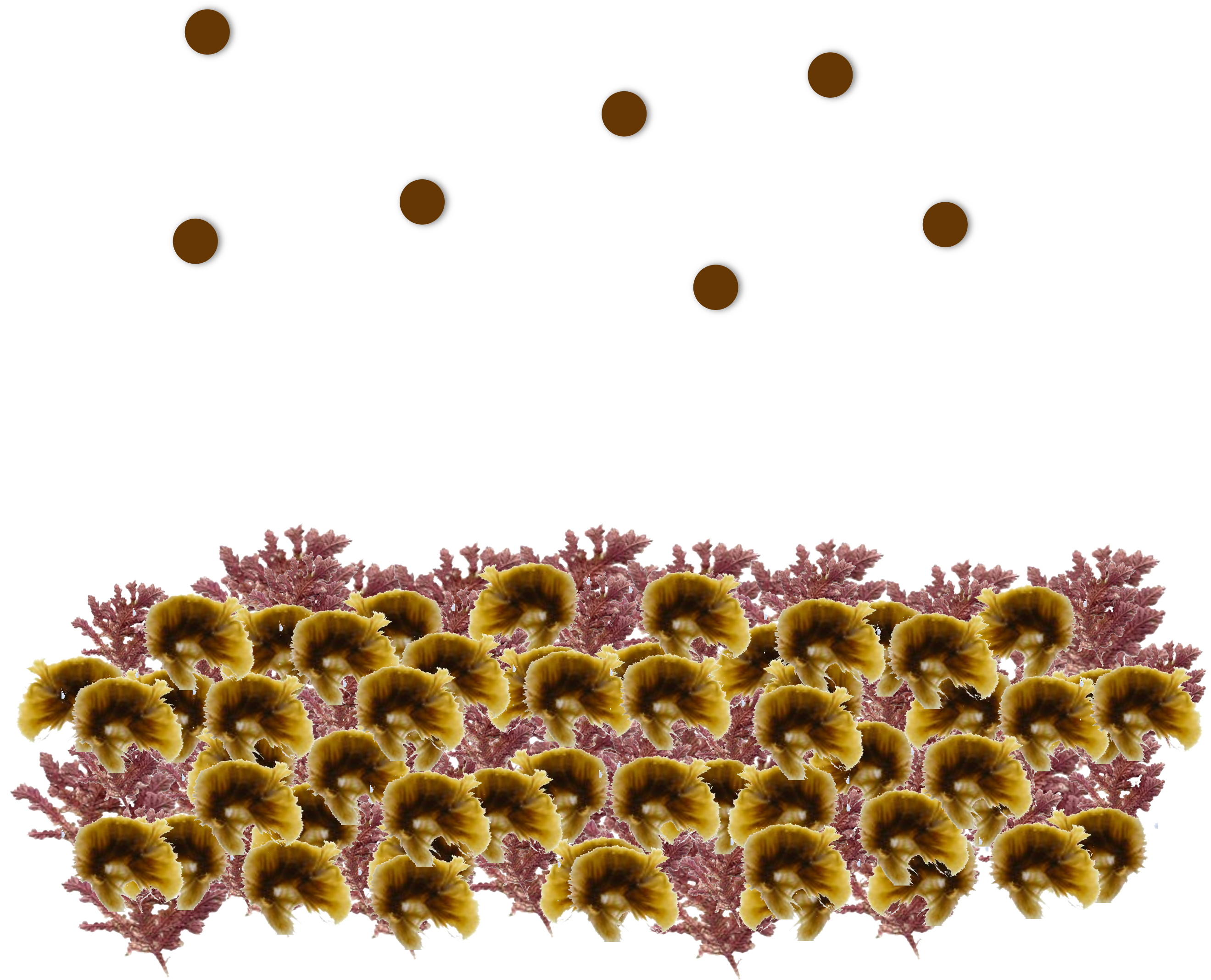






OCEANIC PRODUCTION

Low pH and High Nutrients Scenarios



Mathematics is not a fixed concept,

but a fluid entity that can be replaced, rearranged, and created with artistry

akin to language.

Language Manipulation

Oliver looked around, then ran frantically over the bridge, muttering under his breath.

Having looked around, Oliver ran frantically over the bridge, muttering under his breath.

Oliver looked around. Muttering under his breath, he ran frantically over the bridge.

Frantically, he ran over the bridge, muttering under his breath.

Math Manipulation

$$\frac{d\bar{g}}{dt} = \frac{\sigma_g^2(kt + \epsilon_\theta - \bar{g})}{\sigma_w^2} + \epsilon_{\bar{g}}$$

$$E\left(\frac{d\bar{g}}{dt} \,\middle|\, \bar{g}\right) = \frac{\sigma_g^2(kt - \bar{g})}{\sigma_w^2}$$

$$V\left(\frac{d\bar{g}}{dt} \,\middle|\, \bar{g}\right) = \frac{\sigma_g^2}{N_e} + \frac{\sigma_g^4\sigma_\theta^2}{\sigma_w^4}$$

$$E(r) = r_m - \frac{\sigma_z^2}{2\sigma_w^2} - \frac{k^2\sigma_w^2}{2\sigma_g^4} - \frac{1}{4N_e} - \frac{\sigma_\theta^2}{2\sigma_w^2}\left(\frac{\sigma_g^2}{2\sigma_w^2} + 1\right)$$

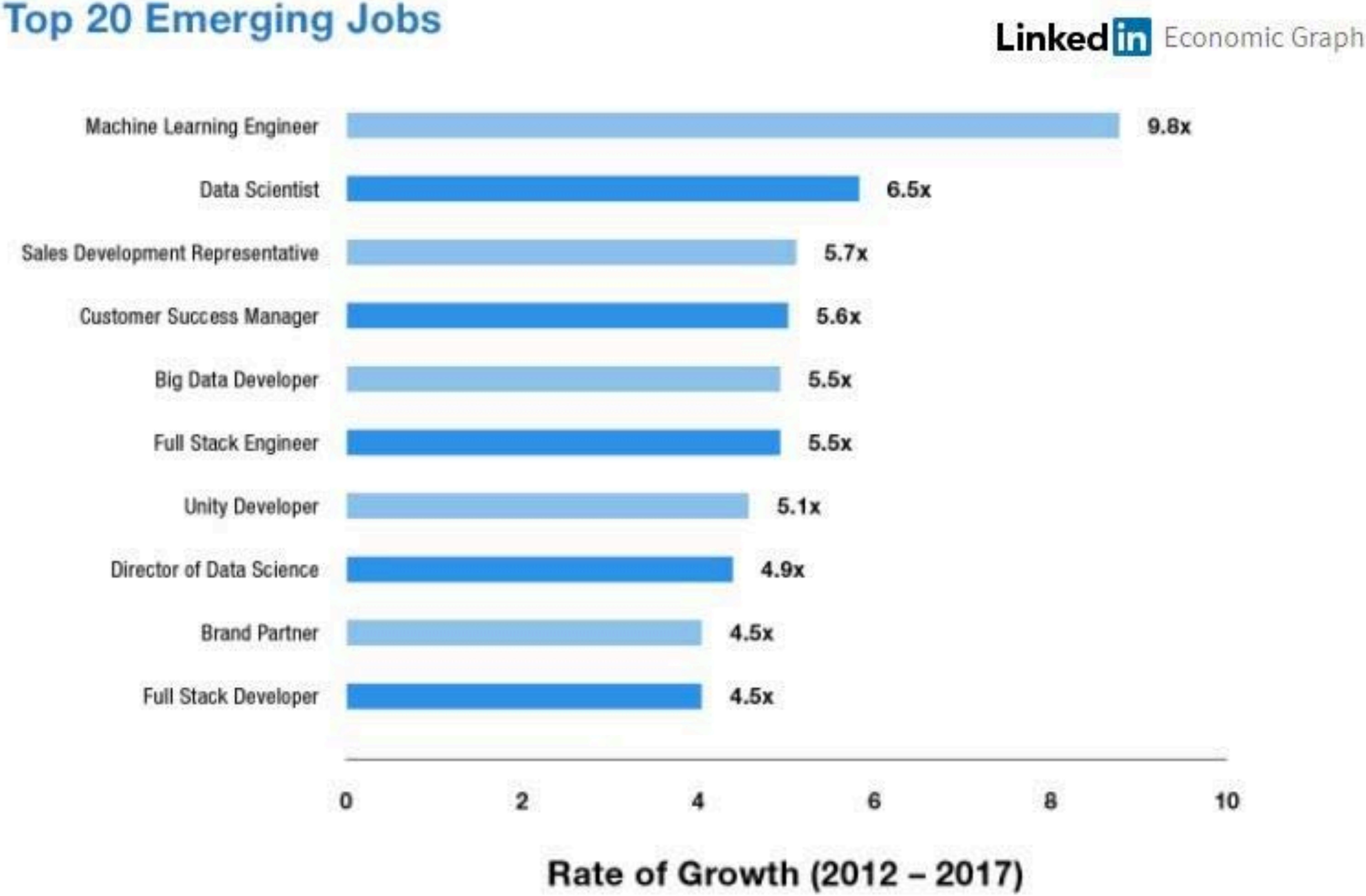

All other teachers


Math mentor

A world driven by DATA

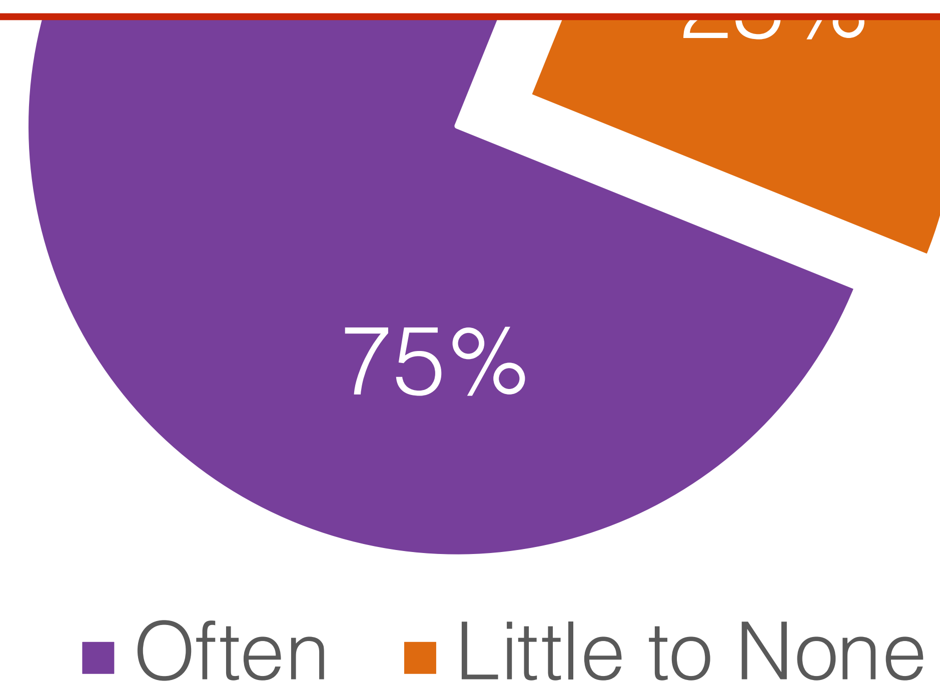
The importance of meaningful representation, number sense/flexibility, and data fluency.

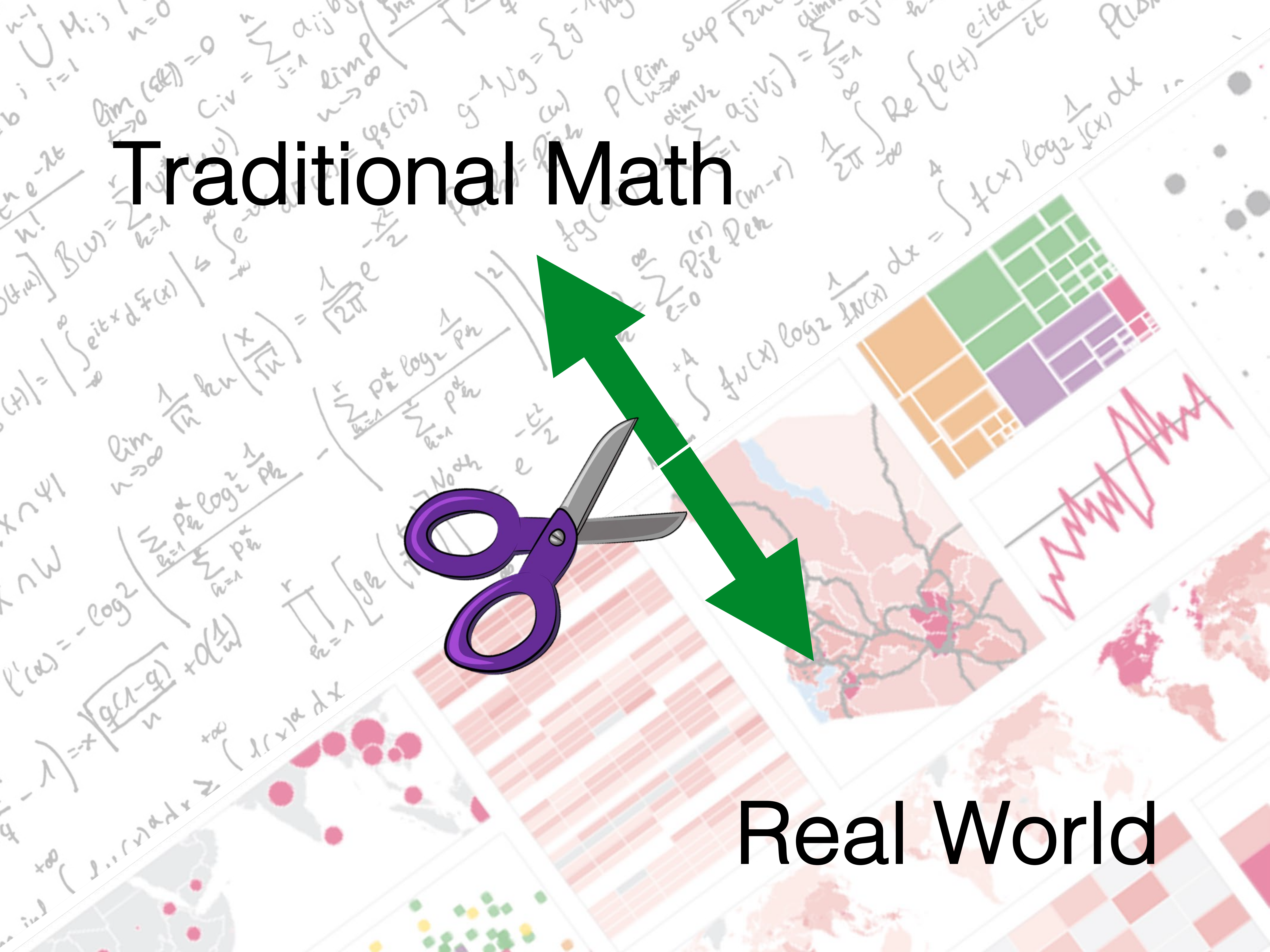
Top 20 Emerging Jobs



Use of Calculus

65% of people say they wished they learned more about how to analyze and interpret data




Traditional Math
Real World

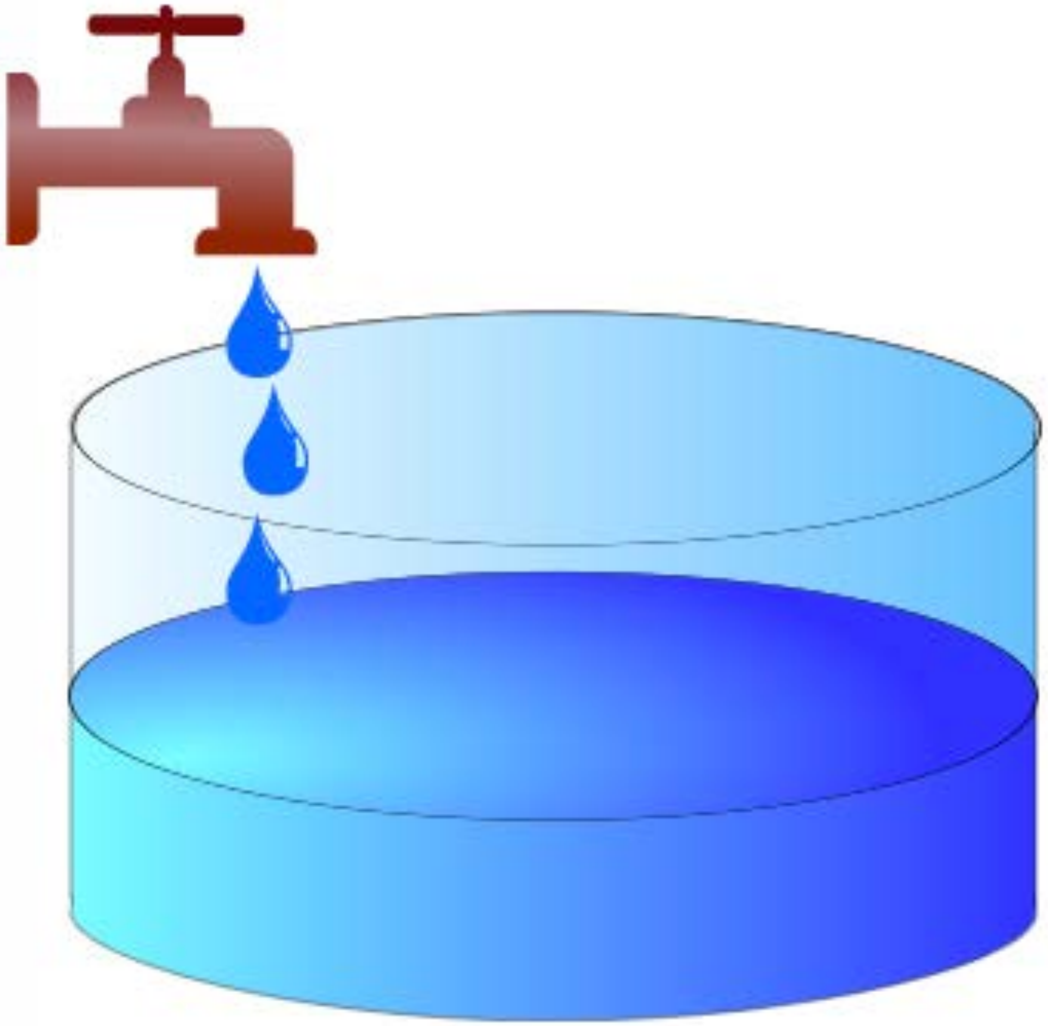
Meaningful Representation

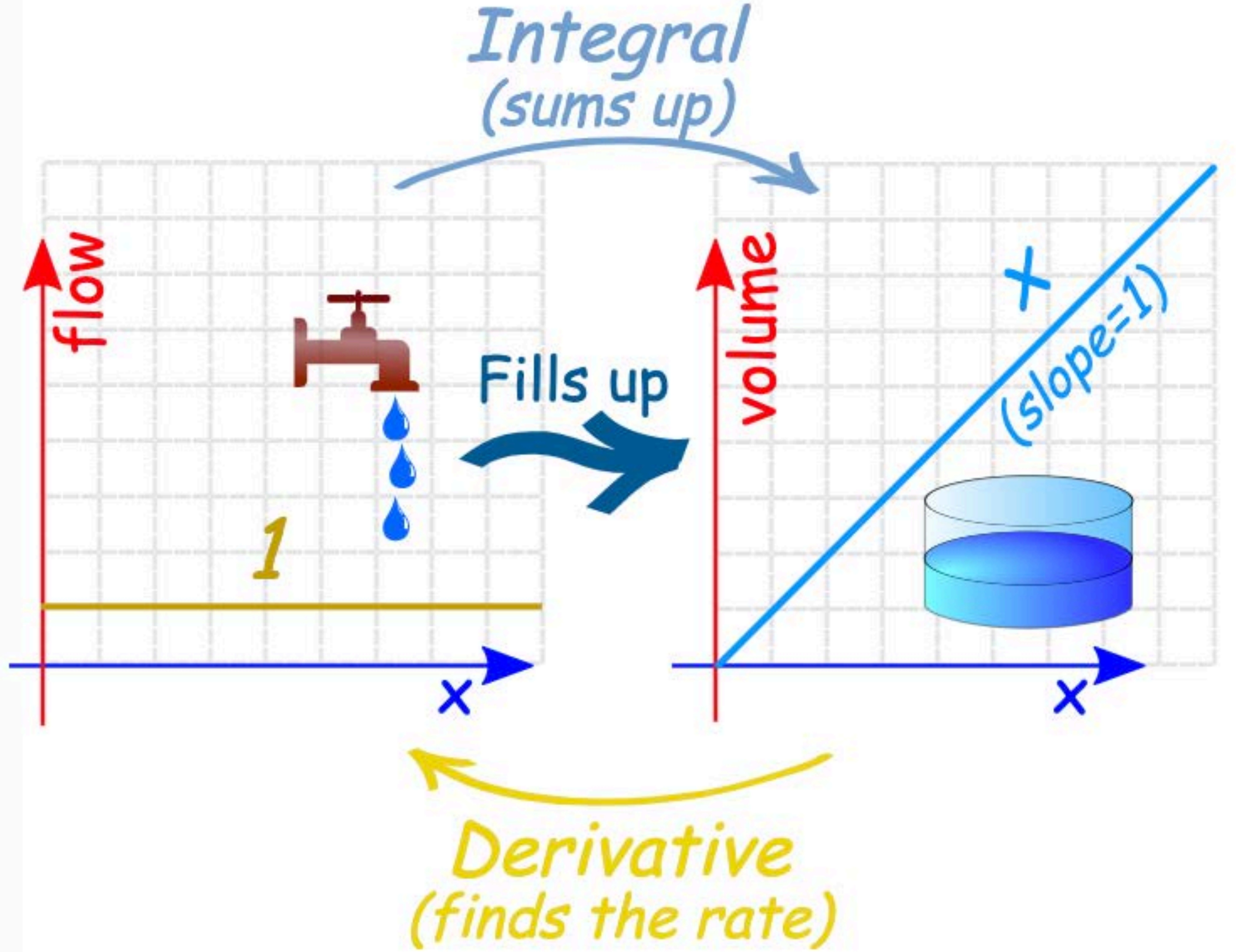
Rationalize the denominator in the equation:

$$\frac{3}{\sqrt{x-7}}$$

Find the imaginary zeros of the equation:

$$f(x) = 4x^4 + 35x^2 - 9$$

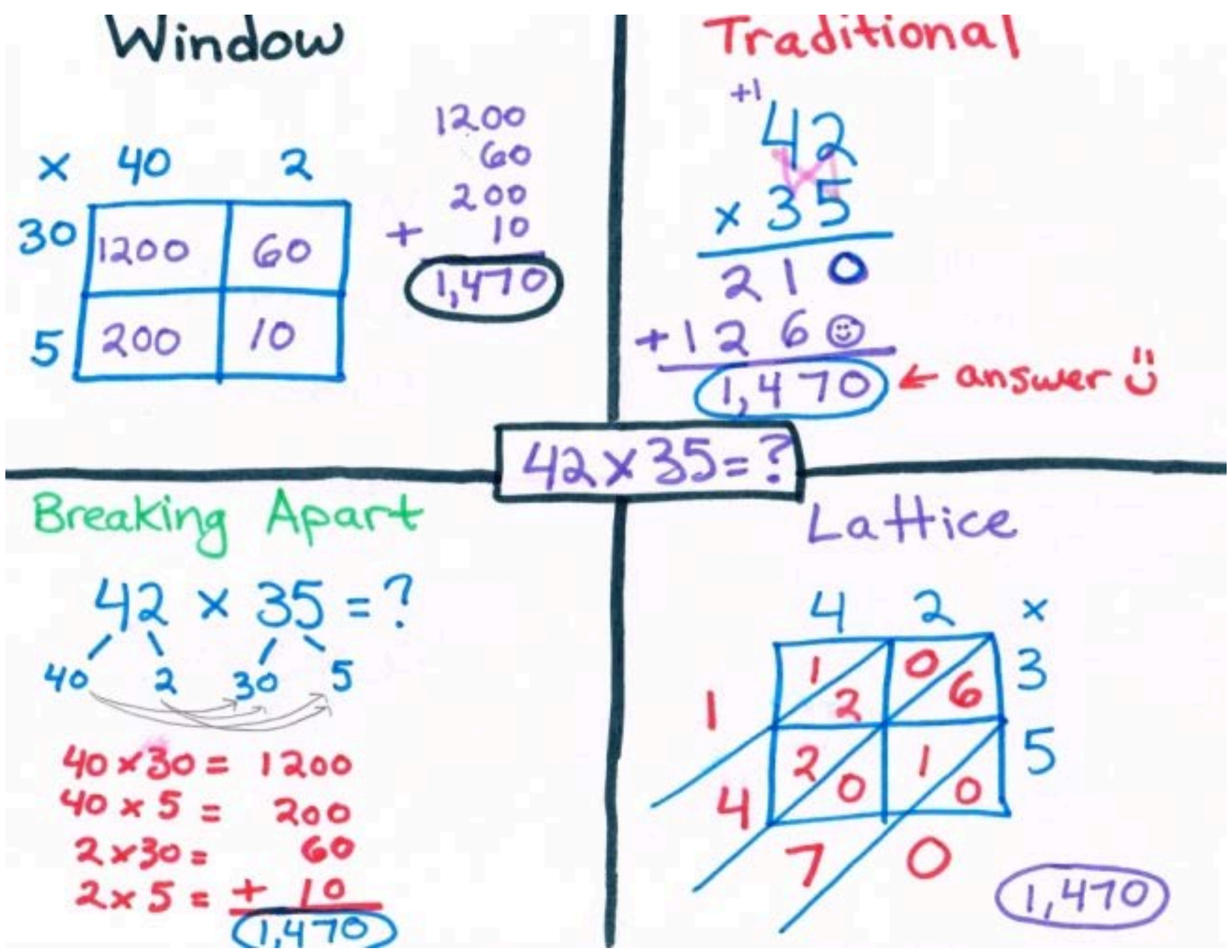




Integral
(sums up)
flow
Fills up
1
x
volume
x
(slope=1)
x
Derivative
(finds the rate)

Number Sense/Math Flexibility

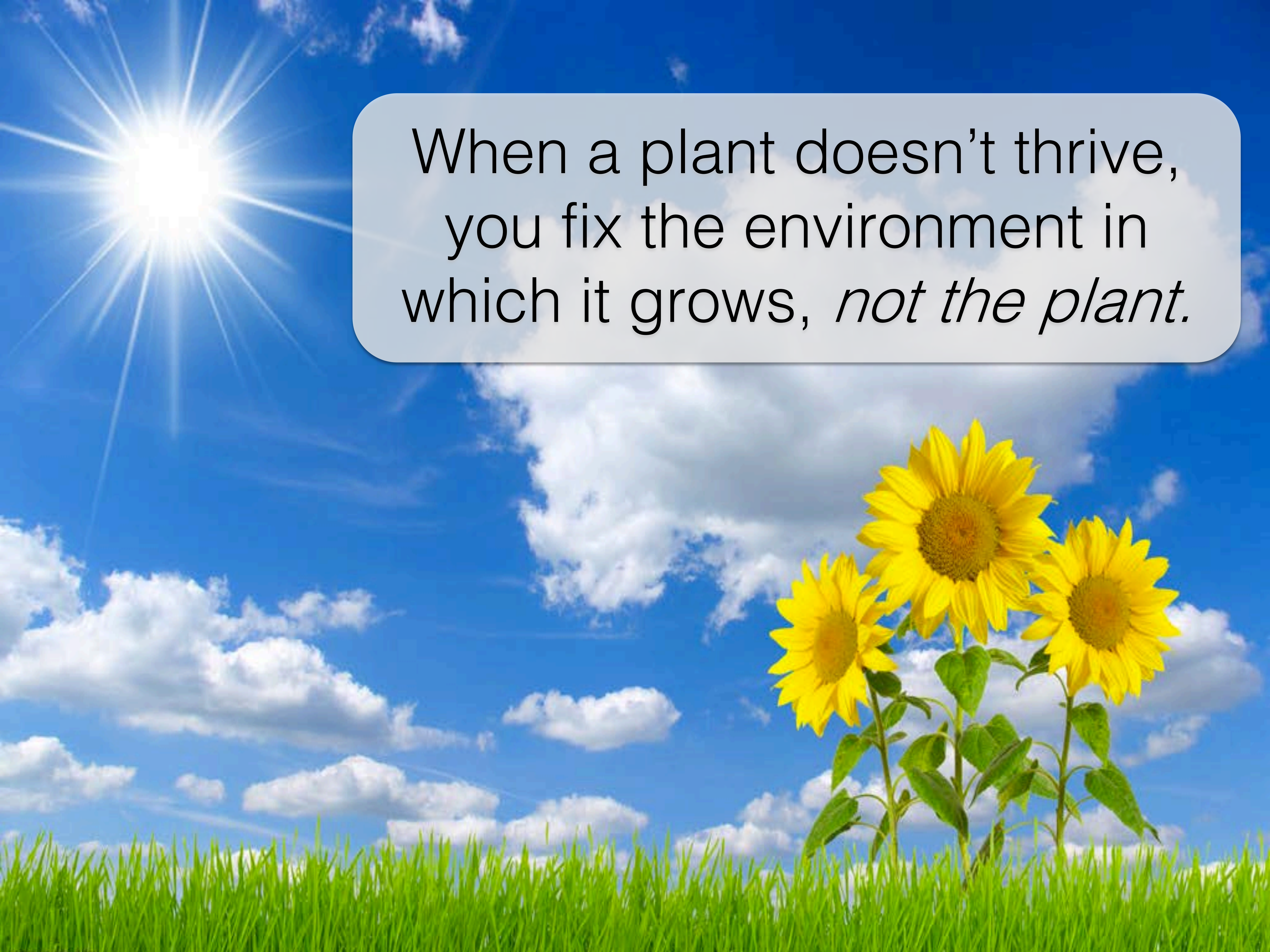
```
  1 1
  469
x  32
-----
  938
```

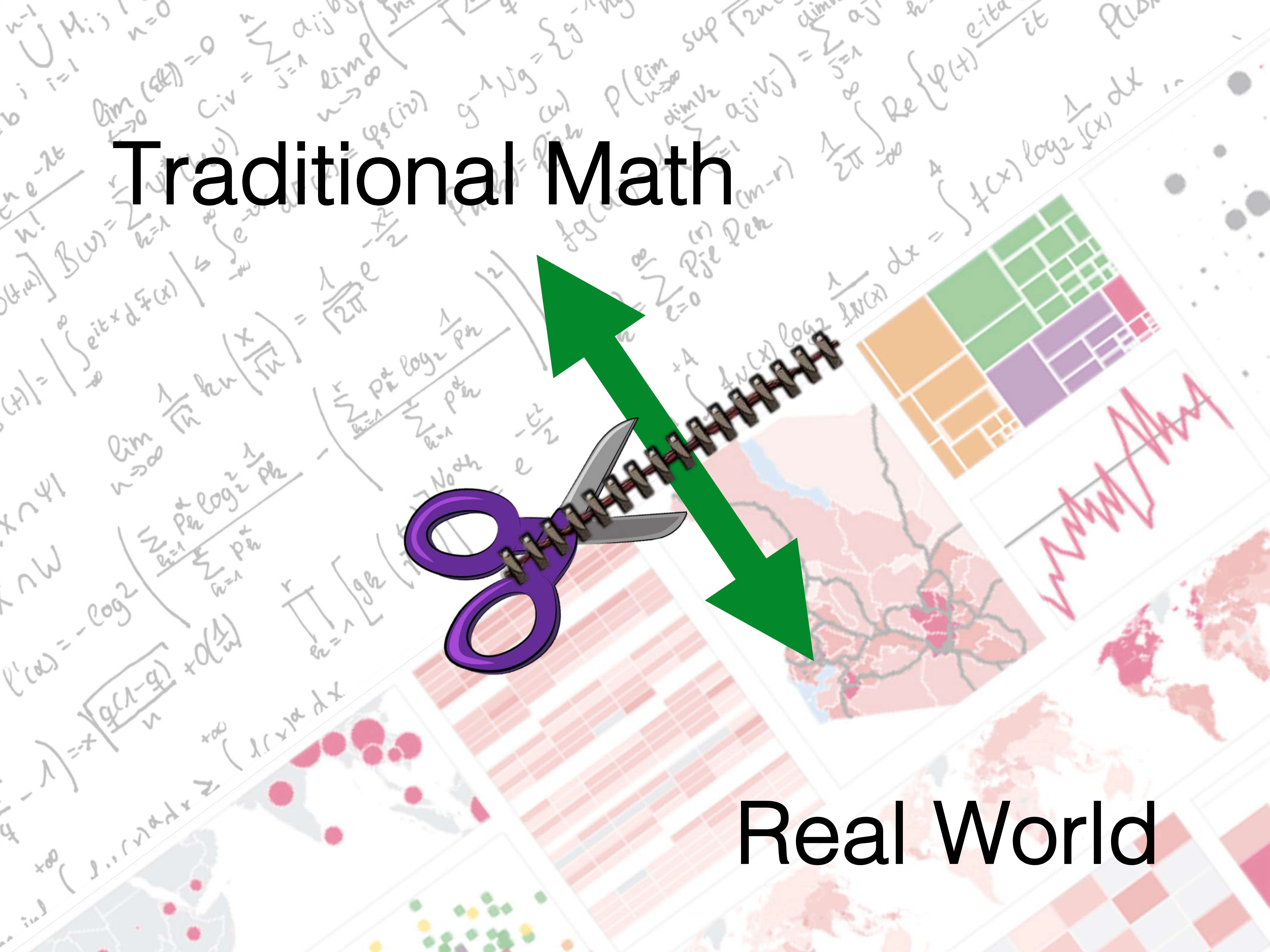


Data Fluency

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Country	Region	Population	Area sq mi	Pop. Density	Coastline (co	Net migratio	Infant morta	GDP ($/capit	Literacy %	Phones	Arable	Crops
2	Afghanistan	ASIA (EX. NE	31056997	647500	48	0	23.06	163.07	700	36	3.2	12.13	0.
3	Albania	EASTERN EU	3581655	28748	124.6	1.26	-4.93	21.52	4500	86.5	71.2	21.09	4.
4	Algeria	NORTHERN A	32930091	2381740	13.8	0.04	-0.39	31	6000	70	78.1	3.22	0.
5	American Sa	OCEANIA	57794	199	290.4	58.29	-20.71	9.27	8000	97	259.5	10	1
6	Andorra	WESTERN EU	71201	468	152.1	0	6.6	4.05	19000	100	497.2	2.22	
7	Angola	SUB-SAHARA	12127071	1246700	9.7	0.13	0	191.19	1900	42	7.8	2.41	0.
8	Anguilla	LATIN AMER	13477	102	132.1	59.8	10.76	21.03	8600	95	460	0	
9	Antigua & Ba	LATIN AMER	69108	443	156	34.54	-6.15	19.46	11000	89	549.9	18.18	4.
10	Argentina	LATIN AMER	39921833	2766890	14.4	0.18	0.61	15.18	11200	97.1	220.4	12.31	0.
11	Armenia	C.W. OF IND.	2976372	29800	99.9	0	-6.47	23.28	3500	98.6	195.7	17.55	2
12	Aruba	LATIN AMER	71891	193	372.5	35.49	0	5.89	28000	97	516.1	10.53	
13	Australia	OCEANIA	20264082	7686850	2.6	0.34	3.98	4.69	29000	[illegible]	565.5	6.55	0.
14	Austria	WESTERN EU	8192880	83870	97.7	0	2	4.66	30000	[illegible]	452.2	16.91	0.
15	Azerbaijan	C.W. OF IND.	7961619	86600	91.9	0	-4.9	81.74	3400	[illegible]	137.1	19.63	2.
16	Bahamas, Th	LATIN AMER	303770	13940	21.8	25.41	-2.2	25.21	16700	[illegible]	460.6	0.8	0
17	Bahrain	NEAR EAST	698585	665	1050.5	24.21	1.05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	Bangladesh	ASIA (EX. NE	147365352	144000	1023.4	0.4	-0.71	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

countries of the world csv


When a plant doesn't thrive, you fix the environment in which it grows, *not the plant.*


Traditional Math
Real World

Change will not come if we wait for some other person… or some other time.

We are the ones we've been waiting for.

We are the change that we seek.

- *Barack Obama*


QUESTIONS?