

# **Environmental Service Learning** Why We Do These Projects:

Invasive Species Removal & Trash Clean Up

**Center for Earth and Environmental Science** 



## Why Do These Projects?

# Invasive Species Removal & Trash Clean Up

Improve water quality.

## What has the nature done for you lately?

**BREATHABLE ATMOSPHERE (O<sub>2</sub>)** 

**EROSION CONTROL** 

#### WATER REGULATION & SUPPLY

watersheds, reservoirs, aquifers

**FLOOD CONTROL** 

**SOIL FORMATION** 

WASTE TREATMENT

RECREATION

#### **NUTRIENT CYCLING**

#### POLLINATION

1/3 of food supply depends on pollinators

**CULTURE** 

#### **RAW MATERIALS**

medicine

fuel

food/fodder

building materials

#### **BIOLOGICAL CONTROL**

predators control prey numbers important in agriculture

#### **GENETIC RESOURCES**

# **ECOSYSTEM SERVICES**

## What has the nature done for you lately?

**Ecosystem Services** are "services" provided by healthy, functional ecosystems (i.e. nature).

Ecosystem Services are often taken for granted because they cost nothing – they are simply present as a consequence of normal environmental processes.

Ecosystem Services are ignored in traditional economic models (because they cost nothing).

Some newer economic models are attempting to take Ecosystem Services into consideration.

What would it cost for humans to replicate the free service that nature provides?

 These estimates are difficult to make.
 IMPORTANT QUESTIONS !!!!

Can humans replicate the free services that nature provides?

Some ecosystem services we cannot (yet) replicate.

As ecosystems become degraded (through species loss, habitat fragmentation, pollution, etc.) their ability to reliably provide ecosystem services also degrades.

By restoring degraded habitats, we help improve ecosystem function and reliability.

## **Healthy Water = Healthy Environment**

One way to improve water quality is to remove sources of water pollution.



## .... it doesn't ensure it, but it contributes to attaining it.

#### **Point Source Pollution**

Single source of a large amount of pollution (e.g. factory that dumps wastes into river)

Fossil fuel extraction and mining are also current point sources.

Most point-sources have been cleaned up since the 1970s. Occasional major accidents are the predominant point sources of pollution today.

#### **Non-Point Source Pollution**

Many small sources, spread over a large area; each contributes a small amount of pollution (e.g. farms, individual homes); large collective impact.

This is more difficult to remediate.

## Many small individual contributions yield major impacts.



## TEAMWORK A Few Harmless Flakes Working Together Can Unleash an Avalanche of Destruction.

In the United States, most pollution today is non-point source.

## Small scale local actions yield large scale regional impacts.

Just as many small individual sources of pollution yield large cumulative impacts, so, too, can many small-scale acts of remediation/ restoration yield large cumulative benefits.



NO SINGLE RAINDROP BELIEVES IT IS TO BLAME FOR THE FLOOD.

CAUSE OF PROBLEM

**SOLUTION** TO **PROBLEM** 



Sewers lead to rivers....

"All drains lead to the ocean, Kid."

- Gill, Finding Nemo

Local pollution does not remain local. Any contaminant that finds its way into local streams and rivers in the Indianapolis area will eventually make its way to the Gulf of Mexico.





Rivers lead to the ocean . . . .

## **Addressing Environmental Pollution of Waterways & Surrounding Areas**





Water pollution falls into two main categories: macro-pollution (the big, easy to see stuff) and micro-pollution (very small, often "invisible" material)

Trash Clean-ups address the issue of



Preventing trash – especially plastics – from making its way to the ocean is one of our goals.

## THE PROBLEMATIC NATURE OF PLASTIC

In the macro-pollution category, plastics have become an increasingly common contaminant.

Plastics are of great concern because, although the material photo-degrades into small pieces, it does not readily biodegrade.

A diamond is forever – so too, for all intents and purposes, is plastic. Plastics begins as and breaks down to small bits known as nerdles.

small photo-degraded plastic bits

Nerdles

pre-production plastic pellets

## **Microbeads**

Extremely Environmentally Detrimental

Some forms of plastic are now recognized as being extremely harmful when released into the environment.

Polyethylene and polypropylene are both recyclable. The problem with microbeads is their size and shape.







They are used in:

## **Exfoliating Body Washes**

## Whitening Toothpastes

#### many other products

Because there were clear-cut, measurable economic impacts, action was taken to prevent microbeads from entering the water treatment system. The only way to do this was to ban the product from certain uses.

#### **Microbead-Free Waters Act of 2015**

#### Phased out of rinse-off products by 2017.

Positive impacts on natural systems of the phase out are a side benefit (not the goal) of the legislation.

## **Microfibers** .... they are everywhere .....

Small fibers break off of clothing when it is washed.

The high speed spin cycles used to remove more water - designed to save time reduce energy use in the dryer - likely exacerbate this problem.

The fibers get washed down the drain and enter our waterways.

This is not good.

Very, very not good.



Together, microbeads, microfibers, and small pieces created when larger plastic items degrade constitute . . . .

**Microplastics** 

. . . . they are unavoidable . . . . .

they are in the foods and beverages that we eat and drink . . . .

the amount is ... concerning ....

https://www.cnn.com/2019/06/11/health/microplasticsingestion-wwf-study-scn-intl/index.html

they are consumed by organisms in the remotest places on Earth, such as deep sea ocean trenches . . . .

they make up part of the sand on our beaches ....



they are being incorporated into newly forming layers of sedimentary rock . . . .

## **Plastic = Pollution Sponge**



#### **Petrochemical (oils)**

similar chemicals stick

Plastics are petrochemicals – a type of oil-based organic compound. Many synthetic organic compounds, such as pesticides, herbicides, flame retardants, etc. are also oil-based. These similar compounds tend to stick to one another.

If a compound is fat-soluble, as many synthetic organics are, it can be stored in the fatty tissues of organisms that ingest it.

Consequently, consumption of plastics may increase the toxin load of an organism, and effects magnify up the food chain.

#### plastic ≠ food

Are these fish eggs .... or colorful nerdles?

Unfortunately, animals can mistake plastics for food.

Many toxic chemicals stick to plastics.

plastic bits acquire a toxic coating

Nerdles and microbeads resemble the food of many aquatic organisms.

Plastic and its toxic load is consumed.

Continued photo-degradation results in tiny pieces of plastic. These tiny pieces are now intermixed with the sand on beaches throughout the world.

Much ends up in the ocean circulating in one of the gyres...

Some exits the gyres and washes back up onshore . . .



& Phillips describes the "discovery" of the Great Pacific Garbage Patch.

Oceanic plastic causes problems for marine life.

### The Fate of Plastics . . . .





Large pieces cause problems such as entanglement.



NOT a jellyfish

Fishing nets that are lost at sea (or deliberately abandoned) become entanglement hazards – especially nets collect due to movement by currents.

Image courtesy Mike Travers (Australian Institute of Marine Science)

> This albatross chick starved to death because it was fed too much plastic and not enough actual food.

Albatross chick

Plastic may be eaten.

Ingested plastic can cause death by choking/intestinal blockage and also by starvation.

ov Iso by

Too much plastic and not enough food is consumed.

Plastics have no caloric value.

sea turtles eat jellyfish

During Service Learning events, we clean up trash in order address the macro-pollutant problem and to help prevent plastics from reaching the ocean.

## **MICRO-POLLUTION**



The main goal of invasive species removal events, however, is to address micro-pollution.

#### EROSION



NUTRIENT TRANSPORT out of the local system

leads to

## SURFACE RUNOFF

Soil particles carried from land to waterways via surface runoff make their way to the ocean. Surface runoff can scar the landscape (erosion) and soil particles (and the nutrients and other chemicals they carry – REMEMBER: sediment particles are sticky) contribute to sediment/nutrient loading of waterways. Sediment is the #1 pollutant in waterways.

Uh oh. That's not good.

Prevention is key!

Sediment is THE #1 POLLUTANT in Indiana waterways.

In 2011, surface runoff containing fertilizers caused algal blooms (some toxic) that covered a third of Lake Erie (photo below).

National Geographic May 2013.

WHEN NUTRIENTS GET INTO WATER. .

# Our Fertilized World

If we don't watch out, agriculture could destroy our planet. Here's how to grow all the food we need with fewer chemicals.

Fertilizer runoff causes toxic algal blooms. This one covered a third of Lake Erie in 2011.

## **EUTROPHICATION MAY RESULT**

Eutrophication is excessive growth of algae caused by nutrient loading.

Sources of nutrient compounds include agricultural operations (crop fertilizers & livestock manure), lawn care (fertilizers) and the natural decomposition of organic material.

Decomposition in natural settings may contribute to small scale, localized eutrophication; it does not typically contribute in a significant way to the high levels of nutrient loading that causes major, large-scale eutrophication events.

### Algae & Cyanobacteria (Blue Green Algae)

Eutrophication of drinking water reservoirs is a continuing problem.

cause

**Problems in Local Waterways:** 

**Aesthetic Issues** 

**Odor issues** 

Toxins (?)

And if algal populations grow to large size in your . .

# they cause Taste & Odor Issues

that are Expensive to Treat

Eagle Creek Reservoir – Indianapolis's source of drinking water – is monitored throughout the spring/summer/autumn.

An ounce of prevention is worth a pound of cure: it is much more cost effective to prevent eutrophication events from happening in the first place than it is remediate the resulting problems after they've occurred.

CEES Service Learning activities contribute to improvements in water quality in central Indiana by reducing sediment/nutrient loading in area streams, lakes, and rivers .....

## **Other Economic Impacts**

Would you want to go spend your Spring Break on this beach?

.... but impacts extend beyond Indiana.

When river systems are involved, there is no such thing as an isolated impact.

Lake Okeechobee

## **Mississippi River drainage**

**Rivers flow.** 

exert effects.

The Mississippi watershed drains a vast area: ~1.2 million square miles. It is the world's fourth largest watershed.



All the material carried by the waters within the Mississippi watershed ends up in the Gulf of Mexico.

sediments nutrients

# All rivers lead to the ocean . . . .



travels declines (precipitously) and sediments carried by the river drop out of the water column and settle to the bottom

The resulting sediment plumes are visible in satellite imagery.

of the Gulf.

- The sediments smothers and kills organisms, and the fertilizers carried along with the sediments promote algal blooms.
- sediment deposition smothers organisms
- fertilizers promote algal blooms
- smothered organisms & algae die
- decomposition of dead organisms by bacteria uses up dissolved O<sub>2</sub>

When algae die, they provide an abundant food resource for decomposer bacteria. Nom nom nom.

Marine algae respond to fertilizers like any other plant/algae: fertilizers stimulate growth.





#### Eutrophication (marine algae, phytoplankton)

Water contains dissolved oxygen  $(O_2)$ . Dissolved oxygen is oxygen that occupies spaces between water molecules; it is not part of a water molecule.



New population explosion: bacterial bloom boom.

# **Result: Dead Zone**

The huge population explosion of bacteria uses up the available dissolved oxygen in the water, resulting in a zone of low/no oxygen.

These waters are referred to as hypoxic (low oxygen) or anoxic (no oxygen), depending on the severity of the problem.



Dissolved O<sub>2</sub> becomes depleted, and animals suffocate.

A "dead zone" (an area where the water is depleted of dissolved oxygen – in other words, it is hypoxic) forms in the Gulf of Mexico every summer.

# **Gulf of Mexico Dead Zone**

How BIG of a problem is it?

Well ..... it depends .... but generally quite large.



Goal = 5000 km<sup>2</sup>

1985-2022. "nd" indicates 'no data'—a year without a completely mapped area or no mid-summer shelfwide cruise (1989 & 2016). In some years the full area was unable to be mapped. The area for 1988 is minimal and not visible on the graph.

5-year running average = 14,000 km<sup>2</sup>

Data source: Nancy N. Rabalais, LUMCON, and R. Eugene Turner, LSU Funding sources: NOAA Center for Sponsored Coastal Ocean Research and U.S. EPA Gulf of Mexico Program



Since sediment and fertilizer runoff from crop fields and lawns in Indiana contributes to the problem, it is logical that steps take in Indiana to prevent sediment loss would help mitigate/reduce the problem.

# How can action taken in Indiana affect what happens in the Gulf of Mexico?

Natural areas can also contribute to sediment loading if bare soil areas develop.

We need to ensure that our sediment stays put.

It's good topsoil. We want to keep it here!

Loss of topsoil in farm fields leads to increased use of fertilizers because more fertilizer is needed to take the place of the nutrients lost with the topsoil ....

This is an example of what is known as a vicious cycle.

# What happens in Indy stays in Indy.

There is a good reason for doing this. The area needs to be made suitable for a house – graded, contoured to promote water flow away from the house's foundation.

Lack of good topsoil is why homeowners tend to use a lot of fertilizer to get a lush, green lawn.

When housing developments are built, the land is stripped of topsoil prior to house construction.

The topsoil is not replaced. The developer can make money be selling the topsoil to a local retailer that sells topsoil, mulch, etc.

Sometimes the topsoil is returned to the property after construction is complete, but generally not.

Sod or grass seed is put down on bare mineral soil. The homeowner then has to fertilize to maintain a lawn.

Strong, deeply rooted plants are key to help hold soil in place and prevent erosion.

#### Plant roots help hold soil in place.

Roots also help water to penetrate into the soil. Plant roots are like roads for water: they create an opening into the soil that the water can follow.

Plants with deep roots encourage movement of water into deeper soil layers. This helps replenish groundwater and reduces surface flow.

Lilly ARBOR

young riparian floodplain forest

Healthy understory native plant community

Eagle's Crest Nature Preserve

mid-aged upland forest

# Encourage the growth of native plants with strong roots.

#### Water movement over bare ground:

- carries away topsoil
  - increased sediment load in the water
- carries contaminants adhering to soil particles
  - nutrients (nitrogen, phosphorus)

One of our goals.

If soil stays in place, then the compounds adhering to the soil particles will also remain land-bound.

So we need to get rid of plants with poor soil-holding capacity.



Our service learning activities focus on natural areas, not agricultural

land or housing developments. So what can we do?????

# Invasive Species Removal

Many CEES Service Learning projects focus on invasive species removal.

#### Why?

Also, why focus on Bush Honeysuckle in particular?

Remember that bit about getting rid of plants with poor soil-holding capacity? Well .....

#### How to identify Bush Honeysuckle:

- leaves & branches arranged in pairs on opposite sides of the sten
- oval leaves with a long pointy tip
- leaf edges smooth
- stems hollow (break easily)
- leafs out earlier than other shrubs
- drops leaves later than other shrubs
- brilliant red berries in autumn



Native plants and animals have a long evolutionary history with one another; for every new "advantage" that has evolved, there has been time for at least one or a few other species to adapt to circumvent that advantage. Consequently, natives are able to exert a degree of control over one another (in terms of population size). Non-natives, because they do not share a long evolutionary history with natives, may present novel characteristics that thwart natives.

We have met the enemy

Generally, a non-native is defined as being from another continent.

**Non-native species** 

**Invasive species** 

Not all non-native species become invasive species.

Non-native, invasive plant species are harmful to the environment for many reasons. In the case of Bush Honeysuckle, one of those reasons is that the plant is very poor at holding soil in place.

Being an invasive species, Bush Honeysuckle is very good at displacing the native plants that are better at holding soil.

and it is Bush Honeysuckle.

Lonicera maackii

## Invasive species are typically superior competitors.

## exclude and displace native species

**Bush Honeysuckle characteristics** that make it a good competitor:

Plants compete viciously with one another for all sorts of resources: light, water, soil nutrients ....

Its numbers are not suppressed by herbivory.

leaves are unpalatable

It gets a head start - growing before trees have leafed out • fast growing and block sunlight from reaching the forest floor.

- leafs out early in the season (less light competition)
- hollow stems (less energy and materials per unit of stem)

Because it has a hollow core, it invests less material per unit length/volume of stem. Consequently, a given amount of material produces a longer stem than it would in a plant that has solid stems.

#### • older shrubs form dense shade\*

bare zone around the plant

alellopathy and shading lead to . .

- poor water percolation to deeper soil layers

Honeysuckle puts more energy into growing shoots & fruits, rather than roots.

#### allelopathic

synthesizes chemicals that kill/suppress other plants

\*Contribute to increased soil loss during periods of surface water flow.

Birds tend to feed and roost in different locations, so seeds are pooped out in a different place than where they were eaten. Result: the plant spreads widely and rapidly.

fruits are attractive to birds

bird dispersed — bird poop

Due to these characteristics (growth rate, shading, allelopathy, not eaten by herbivores), honeysuckle has a significant advantage when competing against other plant species.

- shallow rooted\*
  - does not hold soil well



# Negative Impacts of an Invasive Species

#### Bush Honeysuckle edition.

Note: these impacts are common to most invasive plant species

#### **Decreased biodiversity.**

A diverse forest understory community composed of many different plant species is replaced by a community with fewer species that is dominated by honeysuckle.

Higher levels of biodiversity lead to *decreased* variability in ecosystem function (i.e. functions are more reliable in more diverse habitats).

#### Negative impacts that reverberate up the food chain.

Honeysuckle and many other invasive species have chemical defenses that make the plants unpalatable to native herbivores, so invasives are NOT a good food source for insects (or browsing mammals).

> Look at those leaves: they are mostly intact. At the time of year this photo was taken (mid autumn), leaves of most native plants show significant damage from feeding insects.

A forest with an understory dominated by honeysuckle will support fewer insect species. The decrease in the insect food base will impact the number of insect-eating predators that the area can support.

For example, the area would support fewer insecteating birds.

Fewer birds means fewer bird predators, like hawks .....

# Negative Impacts of an Invasive Species

**Bush Honeysuckle edition.** 

#### Increased sediment loading of waterways.

This is a consequence of honeysuckle being shallow-rooted and killing other plants growing beneath its crown; death – either through allelopathic effects or by depriving the competitor of light (shade death) – of competitors growing beneath the honeysuckle crown leads to development of bare soil areas around the honeysuckle shrub.

Not all invasives contribute to sediment loading.

## Community shows deceased resilience to extreme events.

A less diverse community is less likely to be able to recover quickly from an extreme event such as a drought.

The area will be less resilient to flooding.

Because honeysuckle does not facilitate water movement to deeper soil layers, standing water at the surface would remain at the surface for a longer period.

## Growth of canopy trees is slowed; tree regeneration inhibited.

Allelopathic chemicals slow the rate of growth of trees and inhibit germination and growth of tree seedlings.

These are just a few of the negative impacts that invasive species have on native communities.

# You make a difference!











