The Ecosystem

Ecosystem models
Sun powered autotrophic systems
Heterotrophic systems

Food web
Ecological pyramid
Biomass

Habitats and niches
Species structure, weed problem
Landscape ecology and the human domain
Diversity
Kinds of ecosystems

Population: groups of individuals of any species that live together
in some designated area.

(population) * group of organisms of the same, interbreeding species

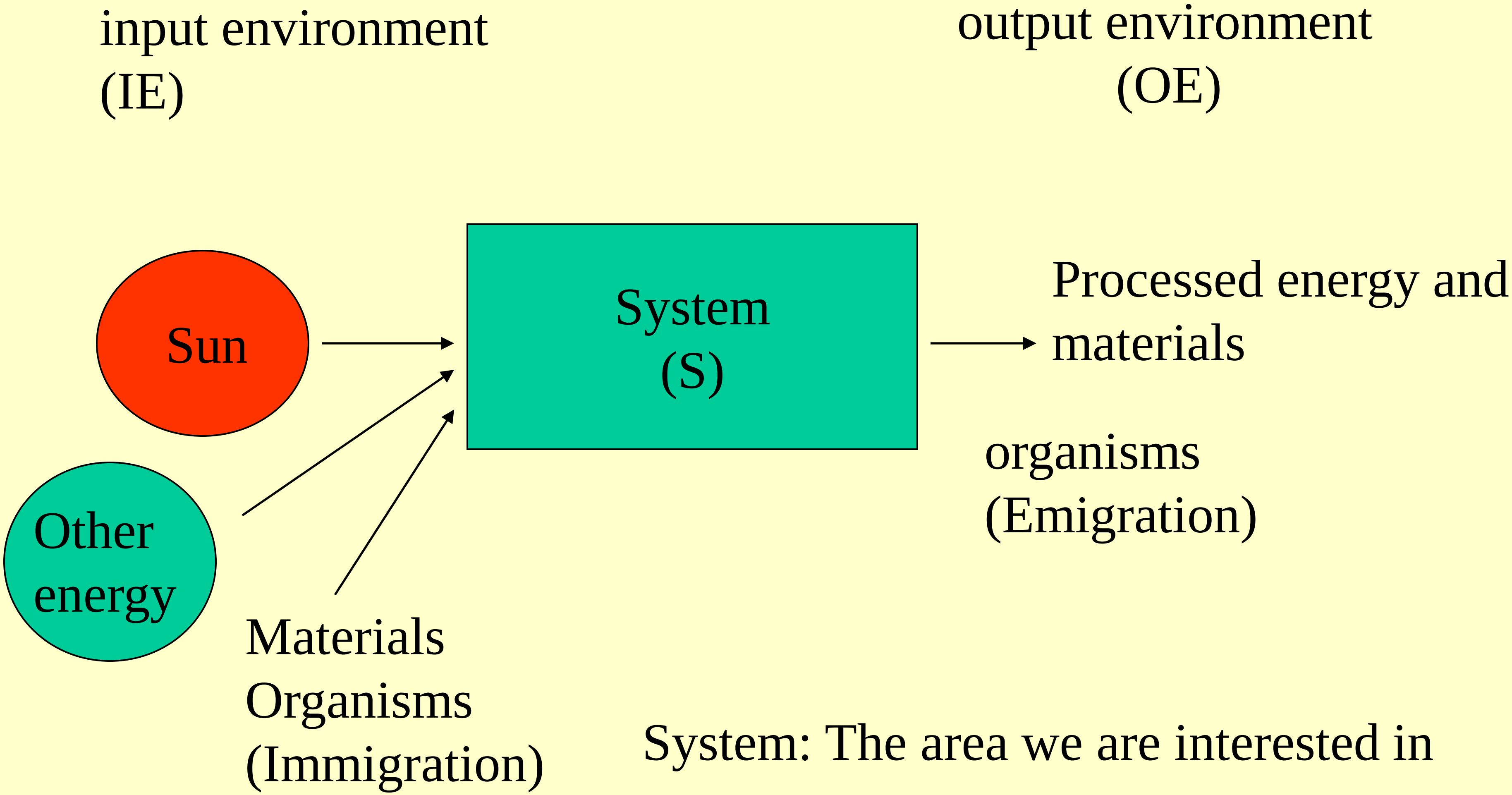
(populations) * group of organisms of different species linked by common ancestry or common habitat

plant populations
bird populations
plankton populations

Community: all of the populations living in a designated area

Ecological system or ecosystem: the community
+
the nonliving environment

ECOSYSTEM MODELS



S

IE

Water

Air

Nutrients

Other materials

Organisms (+Seeds and other reproductive stages)

Constantly enter and leave the system

OE

Energy
(Solar en.
Wind, water flow,
fuel)

Materials

Organisms
(Immigration)

Processed energy and materials
(Heat, organic matter-*food and waste products*- and pollutants)

Organisms
(emigration)

IE + S +OE = Ecosystem

Ecosystem

Biotic

Autotrophic

producers

Heterotrophic

consumers

Abiotic

Inorganic

Biogenic subst.

- **macronutrients**
- **micronutrients**

Organic

Carbohydrates
Proteins
lipids

Organic detritus
DOM
POM
humus

Physical factors

Climate
Physico-chemical nature of soil-water
Geological substrate

Gradient and ecotones
Edge effect

I. Biotic components

1) Autotrophic (self nourishing) components:

Able to fix light energy and manufacture food from simple inorganic substances (water, CO_2, nitrates) by photosynthesis.

PRODUCERS

They form an upper green belt or stratum (layer)

Plants, vegetation, algae, water plants:

2) Heterotrophic (other-nourishing) components

Utilizes, rearranges and decomposes
the complex materials synthesized by the autotrops

“brown belt”

CONSUMERS

Fungi, non photosynthetic bacteria and other microorganisms
animals including humans

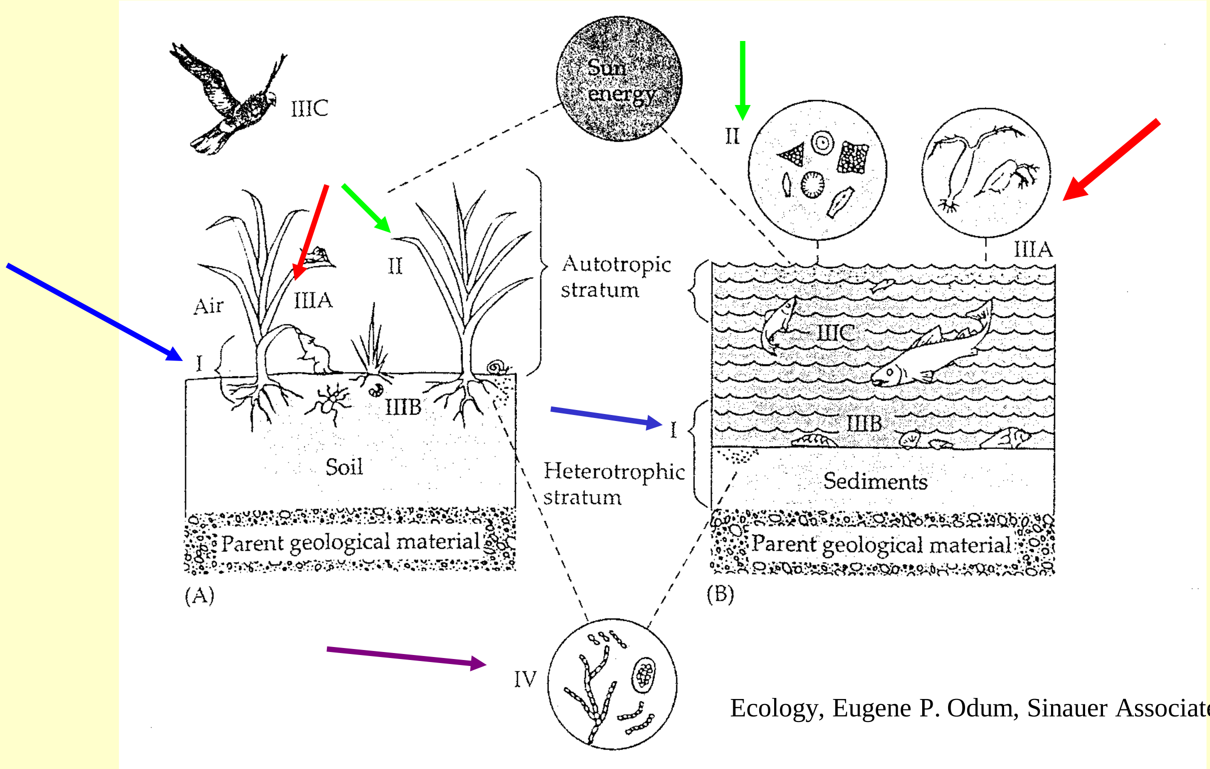
Classification of consumers:
(According to source of their food)

Herbivores: fed on plants
Carnivores or predators: fed on other animals
Omnivores: fed on both plants and animals
Saprovores (Microorganisms and fungi): fed on decaying organic material

On land: predominant autotrops are rooted plants

Ponds, lakes, oceans: suspended plants called phytoplankton (Phyto: plant Plankton: floating) includes algae, green bacteria, green protozoa

Sun Powered Terrestrial and open water ecosystems



Ecology, Eugene P. Odum, Sinauer Associates, Inc., Rev. Ed. of 2nd Ed. 1993

I. Abiotic substances (basic inorganic and organic compounds)

II. Producers: vegetation on land, phytoplankton in water

III. Macroconsumers or animals

A) direct or grazing herbivores (grasshoppers, meadow mice etc on land, zooplankton in water)

B) indirect or detrius-feeding consumers or saprovores (soil invertabrates on land, bottom in water)

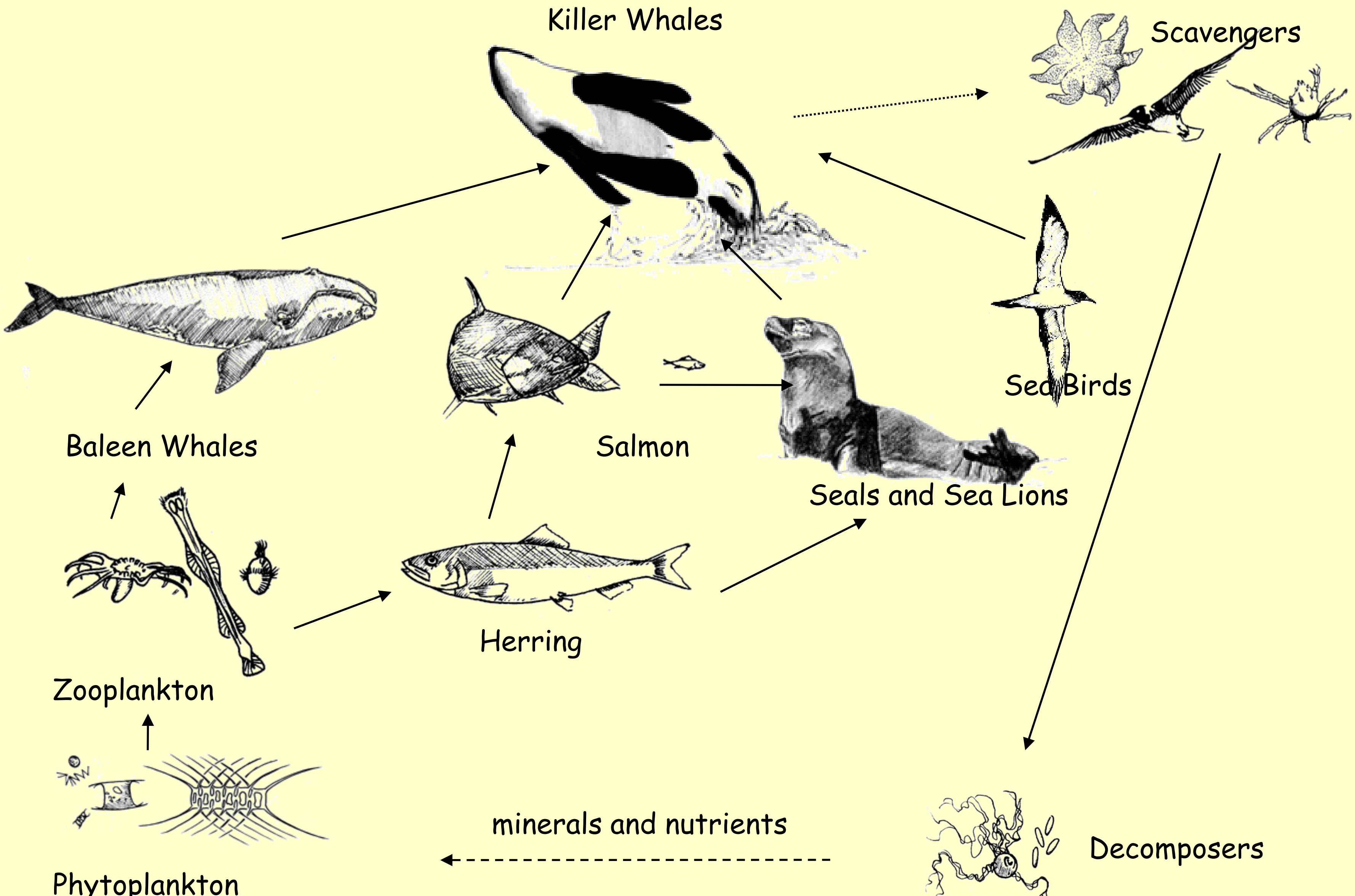
C) top carnivores (hawcs and large fish)

IV. Decomposers (bacteria and fungi)

Food Web

Members of a community depend on each other for survival.
Autotrophic and heterotrophic components are linked
in a network of energy transfer which is called the “food web”.

bioloc.coas.oregonstate.edu/SherrLab/index.html



Decomposer are the organisms that break down the final remains of living things. Predominantly bacteria and fungi, they are important in freeing the last of the minerals and nutrients from organics and recycling them back into the food web.

oceanlink.island.net/oinfo/foodweb/killer.html

A food chain shows how each living thing gets its food

Energy from the sun transferred step by step in the food chain:

Producers (plants, phytoplankton)

Primary consumers

Secondary consumers, ...

Each step in the chain is called trophic level. (This is an energy level not a species level-since any species in a level can utilize more than one level)

Energy pyramid, biomass pyramid

The further along the food chain you go, the less food (and hence energy) remains available.

a large mass of living things at the base is required

to support a few at the top

... many herbivores are needed to support a few carnivores

Terrestial vs aquatic ecosystems

Biomass (living weight) of terrestial systems
may be very different than aquatic systems:

10 000 grams or more / m^2 : forest
5 grams/m^2 : lakes or oceans

5 grams of phytoplankton are capable of manufacturing as much as 10 000 grams of large plants. Because:

- Rate of metobolism of small organisms are very high
- Also photosynthetic material is just 1-5% of the living material of the large plants

Turnover

The ratio of the standing stock of biotic or abiotic components to the rate of replacement of the standing stock.

Example:

Biomass of a forest: 20 000 grams/m^2

Annual growth increment : 1000 grams/year

Turn over time:

20 000/1000 = 20 years (replacement time)

Turnover time on *land*: **long**, maximum biomass accumulates,
Turnover at the autotrophic level in *water*: **short**,very little biomass accumulates (what accumulates in water is animal biomass).

Heterotrophic Ecosystems

In natural and semi-natural landscapes,
autotrophic and heterotrophic activity as a whole tends to balance

Cities, industrialized landscapes consume much more food and organic matter than they produce: *Heterotrophic ecosystems*

Comparison of heterotrophic systems:

Oyster reef: nature's heterotrophic system
City: man made heterotrophic system

} Both must get their Food and energy from outside

(On unit area basis City requires 70 times more energy per day on unit area bases compared to the oyster reef.)

ın order to maintain order:

Food, other energy and materials should be provided
Must be able to assimilate wastes

II. Abiotic components

Two basic abiotic functions make the ecosystem operational:

Energy flow and material cycles

Energy flow:

Into the system: from the sun and other sources through the biotic community and its food web.

Out of the system: as heat, organic material and organisms produced by the system.

Energy flow is one way (although it may be stored and utilized ; sunlight to food)).

Chemical material can be reused again (without the lost of utility). (Biogeochemical cycles Chp.5)

1) Inorganic components:

Among a large number of elements and simple inorganic compounds available, only certain few of them are necessary for life: called as ***biogenic substances or nutrients*** like carbon, hydrogen, nitrogen, phosphorus, calcium.

Those, which are required relatively large amounts, named as *macronutrients.* Abundant amounts can be found in simple compounds which are readily available to organisms: CO_2, water, nitrates.

They also occur in chemical forms that are not readily available: Nitrogen in air must be converted into inorganic salt form by specialized microorganisms. (Phosphorus also).

Micronutrients or trace elements: other elements (as important as macronutrients) required only for small amounts: iron, manganese, magnesium, zinc, cobalt,molybdenum.

2) Organic components:

Carbohydrates (sugar, starches, cellulose)
Proteins (inc. Amino acids)
Lipids (e.g. Fats, oils)

They make up the bodies of living organisms.

<u>Organic detritus</u>: decaying bodies of organisms, dispersed into fragments and dissolved materials.
Two forms of organic detritus are:
DOM: dissolved organic matter. A major reservoir of organic carbon in oceans.
POM: particulate organic matter (converted from DOM, consumed by filter-feeding animans.

Humus or humic substances:

They are formed during breakdown of organic material,
and resistent to further decay.
Chains of aromatic or phenolic benzene rings with
side chains of nitrogen complexes and carbohydrate residues.

They either simulate or inhibit plant growth, depending on
environmental conditions.

3. Physical factors:

Determine the conditions of existance for the biotic community.

Climate
Physico-chemical nature of soil and water
Underlying geological substrata

Gradients and ecotones

Gradients of physical factors characterize the biosphere.

Gradient: the maximum rate at which a physical quantity changes in position.

temperature gradient from the Arctic to the tropics

moisture gradient from wet to dry in weather systems

depth gradient from mountain top to valley

Conditions and the organisms are adapted and change gradually along a gradient. But often, abrupt changes occur. They called ecotones,

Example: prairie-forest junction, or interdial zones in a seacost.

Edge effect:

Sometimes ecotones are populated by *more kinds* and *larger numbers* of animals than the adjoining more homogeneous communities

The Biotic Community: Habitats and Niches

Habitats and niches depend on:

conditions of existance

geography

Each major land mass and each ocean has its own special flora and fauna.

Kangaroos in Australia

Humming birds and cacti in North America

Biogeographic region

is a major level in the ecological hierarchy.

Habitat: The place where a species can be found

Ecological Niche: The ecological role of an organism in its community.

- The place or function of a given organism within its ecosystem.
- Different organisms may compete for the same niche.
- For example, in a forest there may be a niche for an organism that can fly and eat nectar from blossoms.
- This niche may be filled by some sort of bird, or an insect,

The habitat: The organism's address
The niche: its profession

Ecological equivalents:

Example: Kangaroo, bison and cow:

Not closely related genetically, but occupy similar niches when present in a grassland ecosystem.

The biotic community: Species structure

According to their niches (or professions like humans)

Specialist: They feed on a special part of one species.
They become abundant when their sources in ample supply but vulnerable to changes.

Generalist: feed on dozens of different species.
They are more adaptable to changing or fluctuating environment.

Most natural communities contain so many species-
Not possible to take into account all of them

Table 1 Species Structure of the Vegetation of an Ungrazed Tall-Grass Prairie in Oklahoma

Species	Percent of Stand[a]
Sorghastrum natans (Indian grass)	24
Panicum virgatum (Switch grass)	12
Andropogon gerardi (Big bluestem)	9
Ailphium laciniatum (Compass plant)	9
Desmanthus illinoensis (Prickleweed)	6
Bouteloua curtipendula (Side-oats grama)	6
Andropogon scoparius (Little bluestem)	6
Helianthus maximiliana (Wild sunflower)	6
Schrankia nuttallii (Sensitive plant)	6
20 additional species (average 0.8% each)	16
Total	100

9+20 species total 29 species

2 species 36% → The few common species: Ecological dominants

9 species 84%

Remaining 20 species 16%

Species that exert some kind of controlling influence:
Keystone species (regardless of their dominance)

The weed problem

Weed: a species that is in the wrong place in the wrong time.

Table 2 Species Structure of the Vegetation of a Cultivated Millet Field in Georgia

Species	Percent of Stand[a]
Panicum ramosum (Brown-topped millet)	93
Cyperus sp. (Nut sedge)	5
Amaranthus hybridus (Pigweed)	1
Digitaria sanguinalis (Crabgrass)	0.5
Cassia fasciculata (Sicklepod)	0.2
6 additional species (average 0.05% each)	0.3
Total	100.0

Millet field

7% of the plant community consists of 10 other species that have managed to invade the millet crop.

A lot of energy and expensive chemicals (herbicides) required to eliminate the weeds to create monoculture.

Herbicide resistance is a problem!

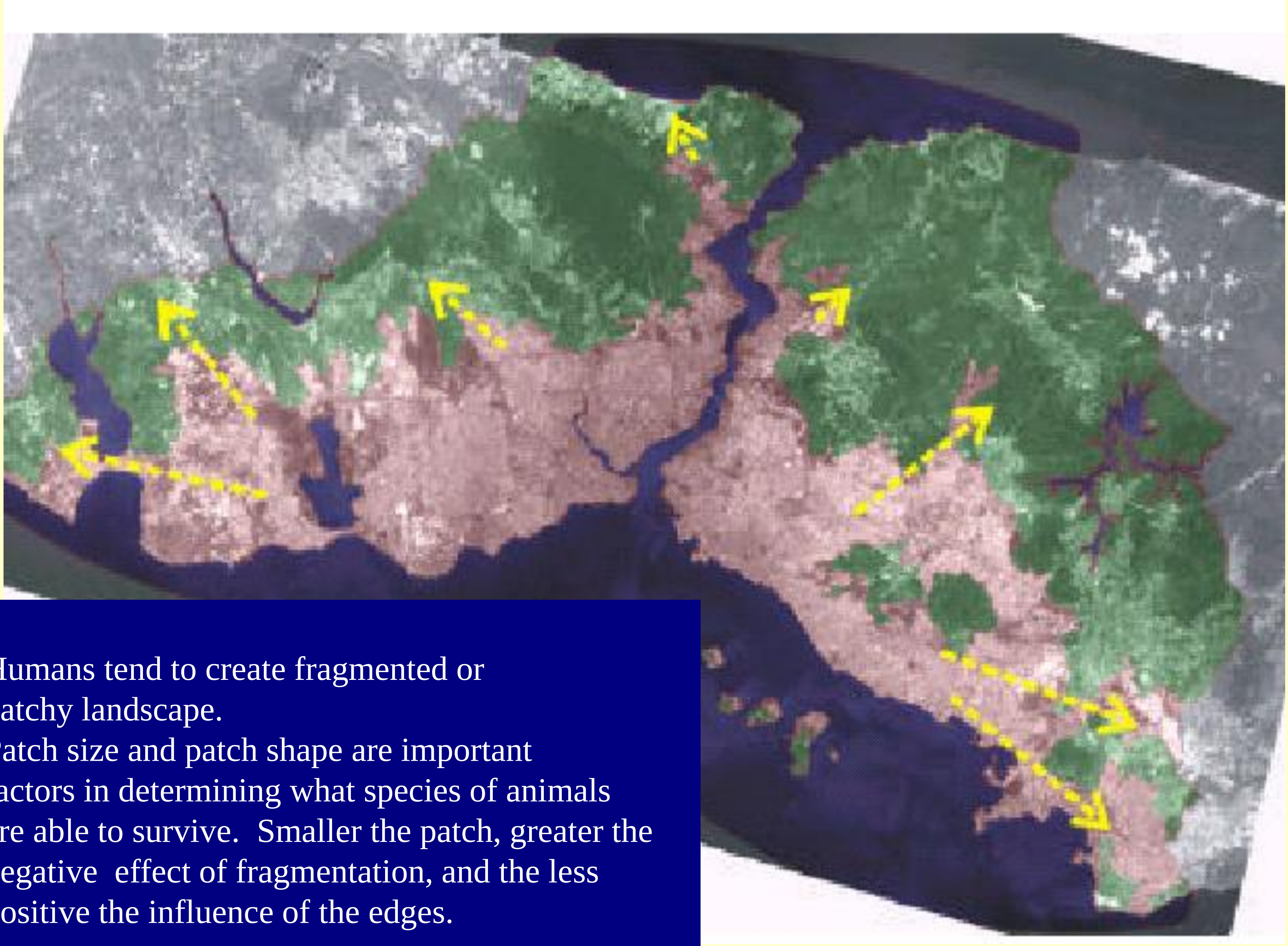
Question:
What are the other alternative ways to eliminate weeds ?

Crop rotation
Weed and weed seed scouting and mapping
Tillage
Spot treatment or banding of herbicides

Landscape Ecology and the Human Domain

Production field: Monocultures –convenient to manage

Protective ecosystems (around homes) increased diversity



Humans tend to create fragmented or
patchy landscape.
Patch size and patch shape are important
factors in determining what species of animals
are able to survive. Smaller the patch, greater the
negative effect of fragmentation, and the less
positive the influence of the edges.

Diversity

Richness or variety

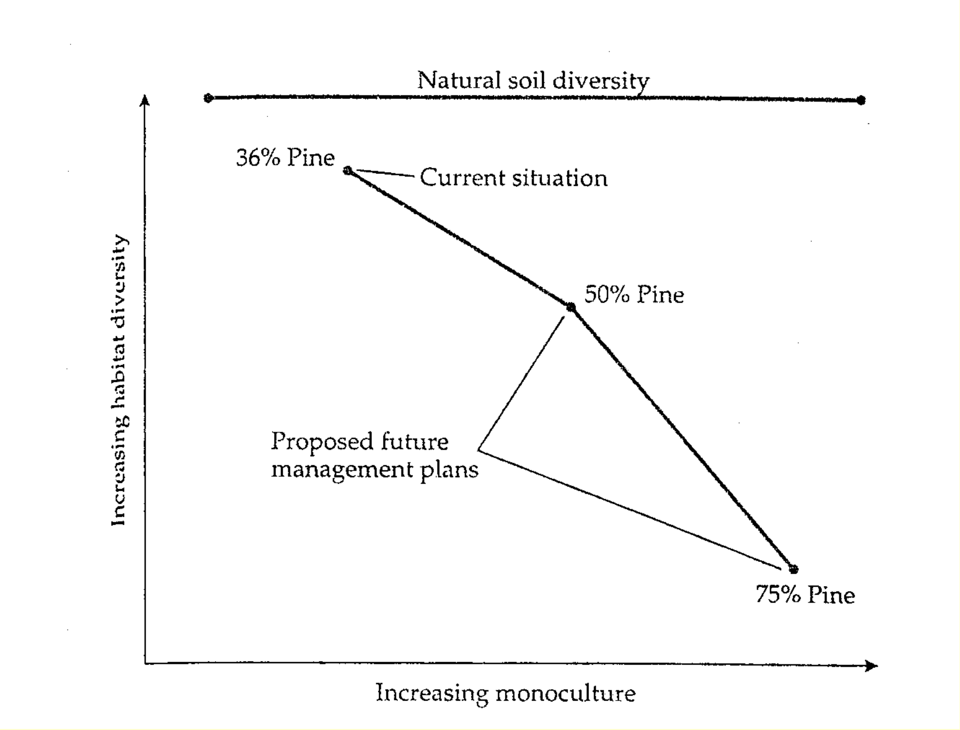
The number of kinds (species, generic varieties, and land use categories)

Relative abundance

Apportionment of individuals among the kinds

Example:
Number of species in each community is ten (*the same richness*).
In one community individuals of each species are about at the same number,
in the second community most of the individuals belong to one
dominant species (different relative abundance)

Landscape Diversity



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As monoculture increasing habitat diversity decreases.

Redundancy (repitation)
Resilience stability (the ability to recover rapidly from disturbances)

are both enhanced by the presence of many different species.

A high species diversity increases resistance stability- (the ability of the ecosystem to remain stable in the face of disturbance)

Kinds of Ecosystems
Biome classification scheme

TABLE 1 Major Ecosystem Types and Biomes of the Biosphere

Marine Ecosystems
Open ocean (pelagic)
Continental shelf waters (inshore water)
Upwelling regions (fertile areas with productive fisheries)
Deep sea (hydrothermal vents)
Estuaries (coastal bays, sounds, river mouths, salt marshes)

Freshwater Ecosystems
Lentic (standing water): lakes and ponds
Lotic (running water): rivers and streams
Wetlands: marshes and swamp forests

Terrestrial Biomes
Tundra: arctic and alpine
Boreal coniferous forests
Temperate deciduous forests
Temperate grassland
Tropical grassland and savanna
Chaparral: winter rain-summer drought regions
Desert: herbaceous and shrub
Semievergreen tropical forest: pronounced wet and dry seasons
Evergreen tropical rain forest

Domesticated Ecosystems
Agroecosystems
Plantation forest and agroforest systems
Rural techno-ecosystems (transportation corridors, small towns, industries)
Urban-industrial techno-ecosystems (metropolitan districts)

Ecoregions: a combination of natural and geographical attributes

Energy based classification: (Chp. 4)

natural

human altered

human made