Community Ecology Problems & Study Questions
Conservation Biology – Biology 114
Spring 2009

1. Using a bomb calorimeter, you determine the following energy values:

Source	Energy content (kJ/g)
Plant material in herbivore's diet	16 kJ/g
Energy stored in average cells of the Herbivore's body	20 kJ/g
Energy stored in herbivore's feces and in other compounds released from its body	10 kJ/g
Energy use by the herbivore during the study time.	

Suppose the herbivore eats 20 g of plant during the study period. The herbivore's dry weight increases by 2.3 g during this time.
(a) What was the dry weight of feces and other released compounds during this time?

THIS PROBLEM IS ALL ABOUT THE CONSERVATION OF MATTER – WE NEED TO BE ABLE TO ACCOUNT FOR EVERYTHING AS INPUT (FOOD) = WASTES + METABOLISM + GROWTH.
WE DON'T KNOW THE TOTAL WASTES AND METABOLISM. LET'S CALL IT "X."

20G = X + 2.3G X = **17.7 G**

(b) How much energy entered the herbivores body in the food it ate during the study?

IT ATE 20 G AND EACH GRAM CONTAINS ABOUT 16 KJ/G. THEREFORE THE TOTAL AMOUNT OF ENERGY ENTERING WAS 20*16KJ/G=**320 KJ.**

(c) How much energy left the herbivore's body as undigested or discarded matter?

THE HERBIVORE DID NOT ASSIMILATE 17.7 G OF THE 20 G OF PLANTS IT ATE (see answer A).
THE CALORIC VALUE OF THIS MATERIAL IS GIVEN ABOVE AS 10 KJ/G, THEREFORE, ENERGY NOT ASSIMILATED WAS 17.7 G * 10 KJ? G = 170 KJ

(d) What is the ecological efficiency of the herbivore?
EE = ASSIMILATED ENERGY/ENERGY TAKEN IN
FIRST WE NEED ASSIMILATED ENERGY
ASSIMILATED ENERGY = GROWTH (G) * ENERGY/GRAM OF GROWING ORGANISM = 2.3 G * 20 KJ/G = 46 KJ
THEREFORE: EE= ASSIMILATED ENERGY/ENERGY TAKEN IN = 46 KJ/320 = **0.14 (14%)**

2. Suppose that 100,000,000 Joules of sunlight is captured by producers per hectare of land. Furthermore, suppose that the ecological efficiency of moving up each rung of a food chain in this place is 10%. Finally, suppose the following energy requirements:

Given Data:		Energy Available	max # individuals
		100,000,000	
Average herbivore	10	10,000,000	1,000,000
Average primary carnivore	20	1,000,000	50000
Average secondary Carnivore	50	100,000	2000
Average tertiary Carnivore	100	10,000	100
Quaternary Carnivore	1000	1,000	1

Based on the given ecological efficiency, how much energy is theoretically available to each level of this food chain?

THIS IS GIVEN IN COLUMN #3 – CALCULATED BY MULTIPLYING THE ECOLOGICAL EFFICIENCY (0.1) TIMES THE ENERGY AVAILABLE AT THE PREVIOUS (LOWER) TROPHIC LEVEL. FOR EXAMPLE, IF 100,000,000 J ARE AVAILABLE FROM AUTOTROPHS (PRIMARY PRODUCERS) AND IF 10% OF THIS IS TRANSFERRED TO THE NEXT TROPHIC LEVEL (HERBIVORES), THEN 10,000,000 J ARE STORED IN HERBIVORES.

PUT ANOTHER WAY, IF 100,000,000 J OF PLANT MATERIAL IS HARVESTED BY HERBIVORES, THEN 10,000,000 OF THIS IS STORED IN THEIR BODIES AS GROWTH (AND REPRODUCTION) AND THE REST WAS LOST IN FECES AND IN RESPIRATION.

How many levels can be sustained with this much primary production? (Hint – you will not be able to sustain all).
WE NEED TO CALCULATE THE NUMBER OF INDIVIDUALS THAT CAN BE THEORETICALLY SUSTAINED AT EACH LEVEL. THIS WOULD BE EQUAL TO THE TOTAL AMOUNT OF ENERGY AVAILABLE AT THAT LEVEL DIVIDED BY THE ENERGY CONTAINED IN EACH INDIVIDUAL. THIS IS SHOWN IN COLUMN #4. FOR EXAMPLE, SINCE THERE IS 10,000,000 J AVAILABLE FOR HERBIVORES AND THE AVERAGE HERBIVORE CONTAINS 10 J OF ENERGY, THEN 10,000,000 / 10 =

1,000,000 HERBIVORES (THESE ARE OBVIOUSLY SMALL HERBIVORES – SUCH AS INSECTS).
THEORETICALLY, ALL LAYERS COULD BE SUSTAINED BUT THE POPULATION OF TOP CARNIVORES IS SO SMALL (ONLY 1 INDIVIDUAL) THAT IS UNLIKELY UNLESS THERE ARE OTHER ADJACENT AND SIMILAR PATCHES OF LAND.

What does this mean about ecosystem structure?
ENERGY AVAILABILITY LIMITS FOOD CHAIN LENGTH AND NUMBERS OF ORGANISMS AT DIFFERENT LEVELS – THUS IT HELPS TO DETERMINE COMMUNITY COMPLEXITY

Beyond energy -- what does this illustrate about pyramids of biomass and numbers?

NOTE THE CLASSIC TERRESTRIAL FIELD (NOT FOREST) PYRIMID OF NUMBERS WITH PLANTS THE MOST NUMEROUS AND TOP CARNIVORES THE LEAST. THE SAME IS TRUE ABOUT BIOMASS IN THIS CASE.
NOTE ALSO THE OBVIOUS SIZE DIFFERENCES IN TYPICAL INDIVIDUALS AT EACH TROPHIC LEVEL – OVERALL, MOST HERIBVORES ARE SMALL (INSECTS ECT) AND IT IS COMMON FOR TOP CARNIVORES TO BE RELATIVELY LARGE.