OSU~EmEA - 17

Emergy Evaluation of Alternatives

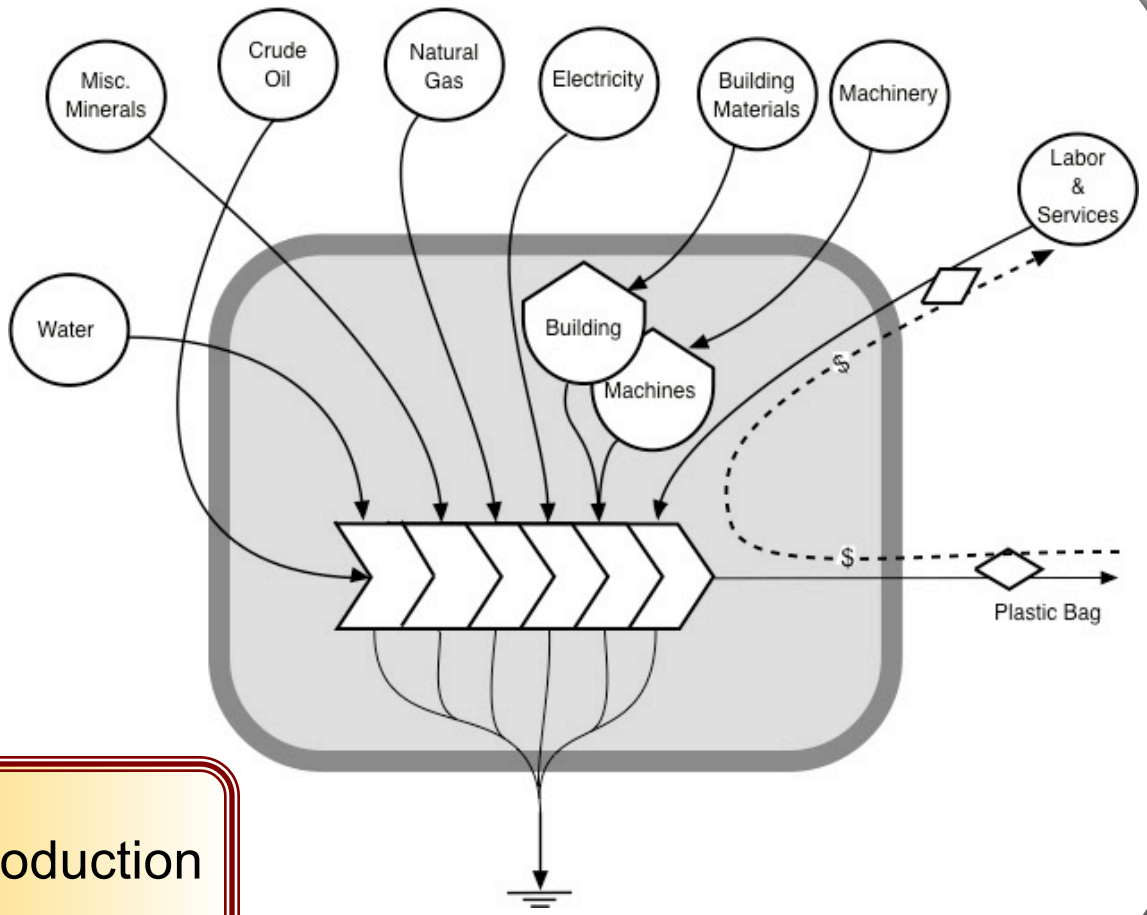
Environmental Accounting
And Decision Making

Evaluation of Alternatives…

- Paper or plastic?
- Disposable or Cloth Diapers?

Based on analyses done by Matt Cohen

Evaluation of Alternatives...



Plastic Bag Production

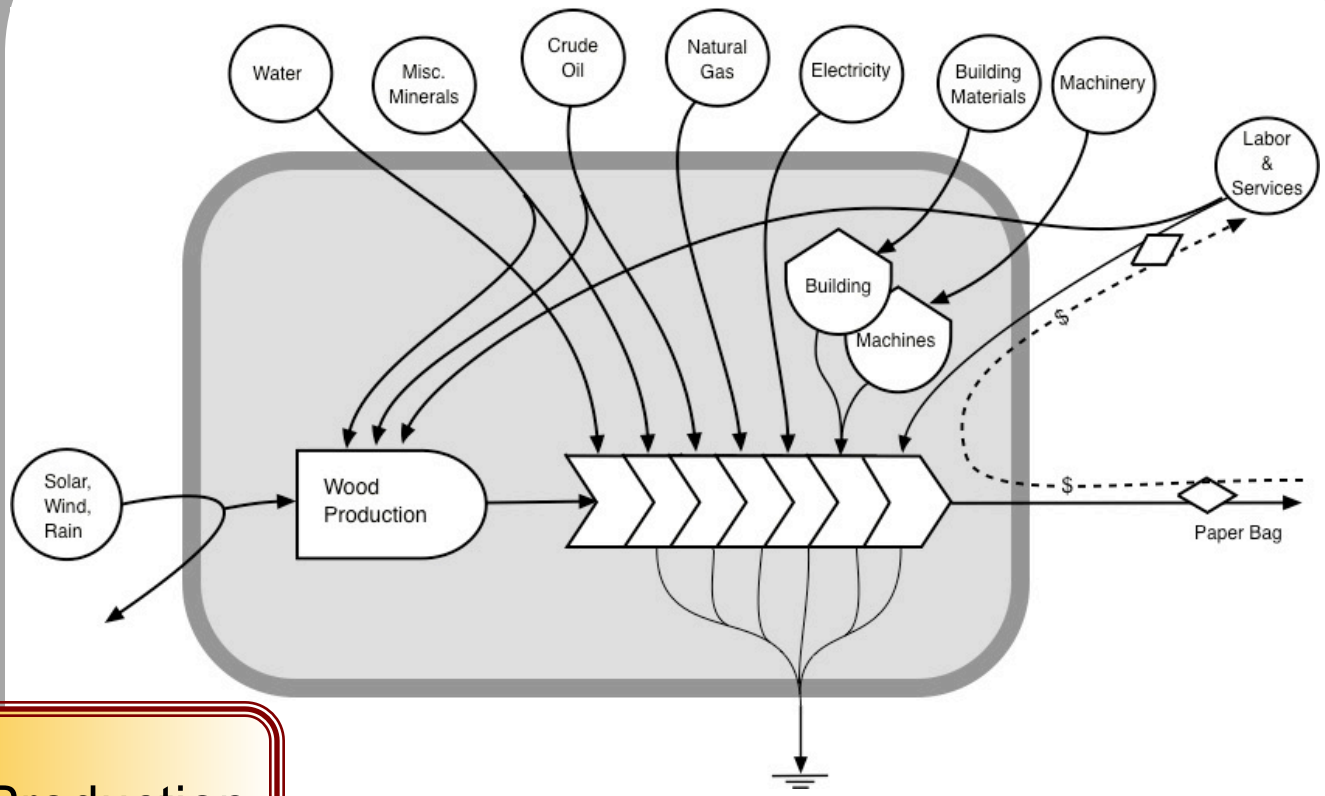
Evaluation of Alternatives…

Emergy Evaluation of Plastic Bags

Note	Item	Data	Units	UEV (sej/unit)	Emergy (E9 sej)
Inputs					
1	Water	3.00E+01	kg	1.00E+08	3.0
2	Misc Minerals	1.70E+00	kg	5.00E+10	85.1
3	Crude Oil	9.10E-01	kg	5.79E+12	5268.9
4	Natural Gas	7.30E-01	m^3	5.46E+12	3985.8
5	Electricity	2.10E+06	J	2.21E+05	464.1
6	Bldg. Materials	5.74E-02	kg	2.90E+12	166.5
7	Machinery	1.72E-03	kg	1.80E+14	309.6
8	Labor & Services	6.35E+00	$	1.90E+12	12.1
Output					
9	Plastic bags	1.67E+02	#	**6.16E+10**	1.03E+13

Emergy per Plastic Bag

Evaluation of Alternatives...



Paper Bag Production

Evaluation of Alternatives…

Emergy Evaluation of Paper Bags

Note	Item	Data	Units	UEV (sej/unit)	Emergy (E9 sej)
Inputs					
1	Renewable	1.06E+06	J	7.00E+03	7.4
2	Water	1.27E+02	kg	1.00E+08	12.7
3	Misc Minerals	1.70E+00	kg	5.00E+10	85.1
4	Misc. Chemicals	2.90E-02	kg	1.00E+12	29.0
5	Crude Oil	3.50E-02	kg	7.26E+12	254.1
6	Natural Gas	5.51E-01	MJ	1.46E+11	80.4
7	Electricity	9.46E-01	kwh	1.45E+12	1371.7
8	Bldg. Materials	3.54E-02	kg	2.90E+12	102.7
9	Machinery	1.62E-03	kg	1.80E+14	291.6
10	Labor & Services	3.87E+00	$	1.90E+12	7.4
Output					
11	Paper Bag	1.50E+01	#	**1.49E+11**	2.23E+12

Emergy per Paper Bag

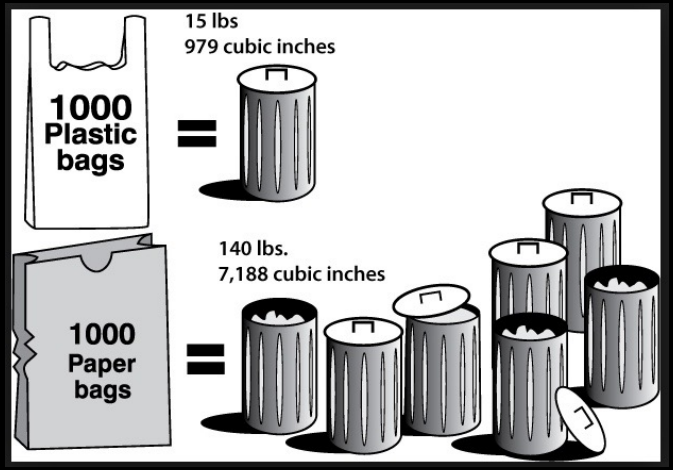
Evaluation of Alternatives...

A packed standard-sized paper bag can hold an average of 14 items, an average plastic bag can hold 8 items. Therefore, it takes 1.75 plastic bags to equal 1 paper bag.

Paper bag = 1.49 E11 sej/bag

Plastic bag = 6.16 E10 sej/bag
= 1.75 * 6.16 E10
= 1.08 E11 sej

In addition, plastic bags generate 80% less solid waste...but require about 10 years to decompose while paper decomposes in about 1 month.



Disposable or Cloth Diapers?

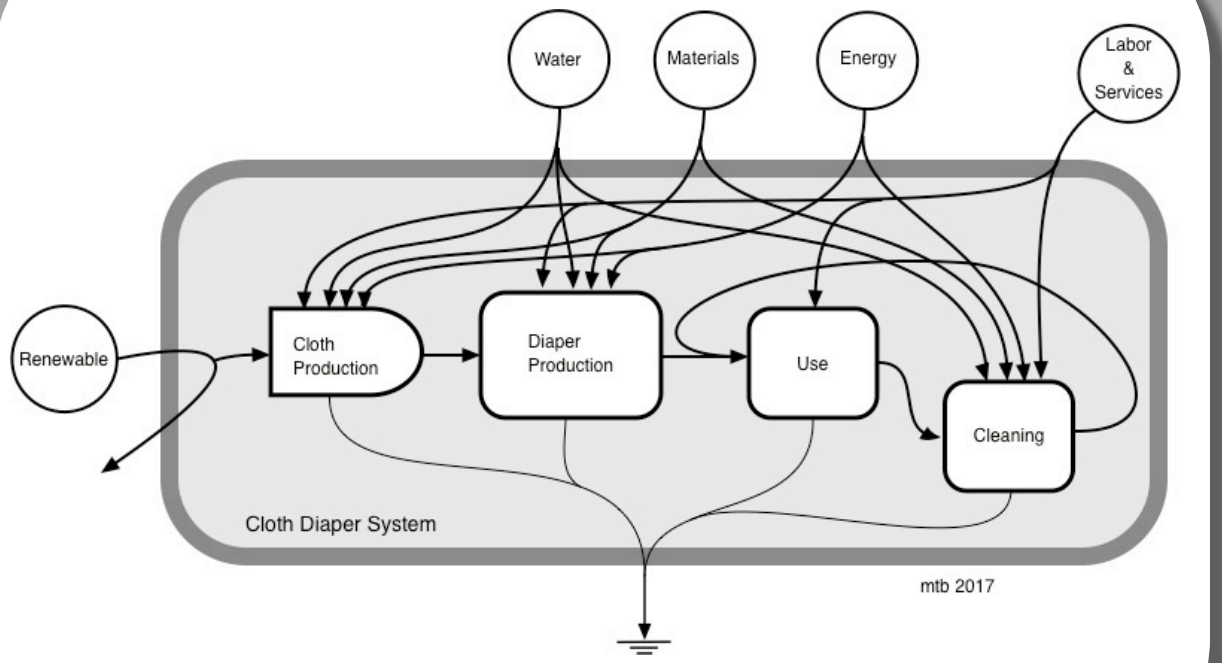
Disposable diaper

Cloth diaper washed at home

Cloth diaper – diaper service

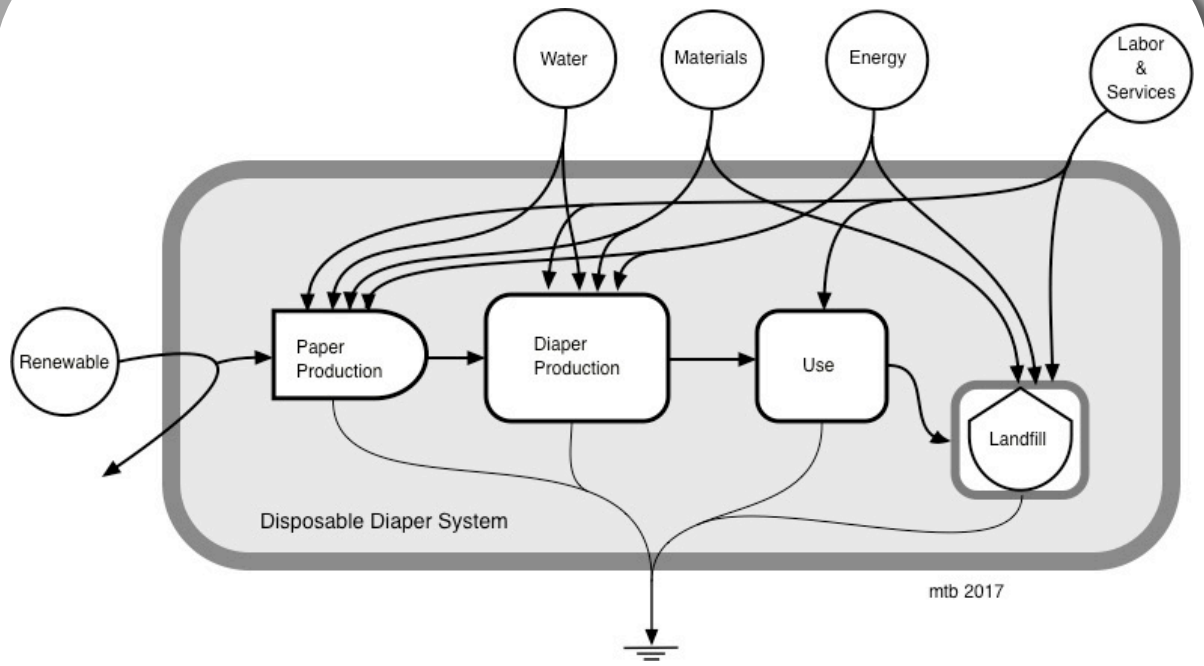
Evaluation of Alternatives…

Cloth Diaper System



Evaluation of Alternatives…

Disposable Diaper System



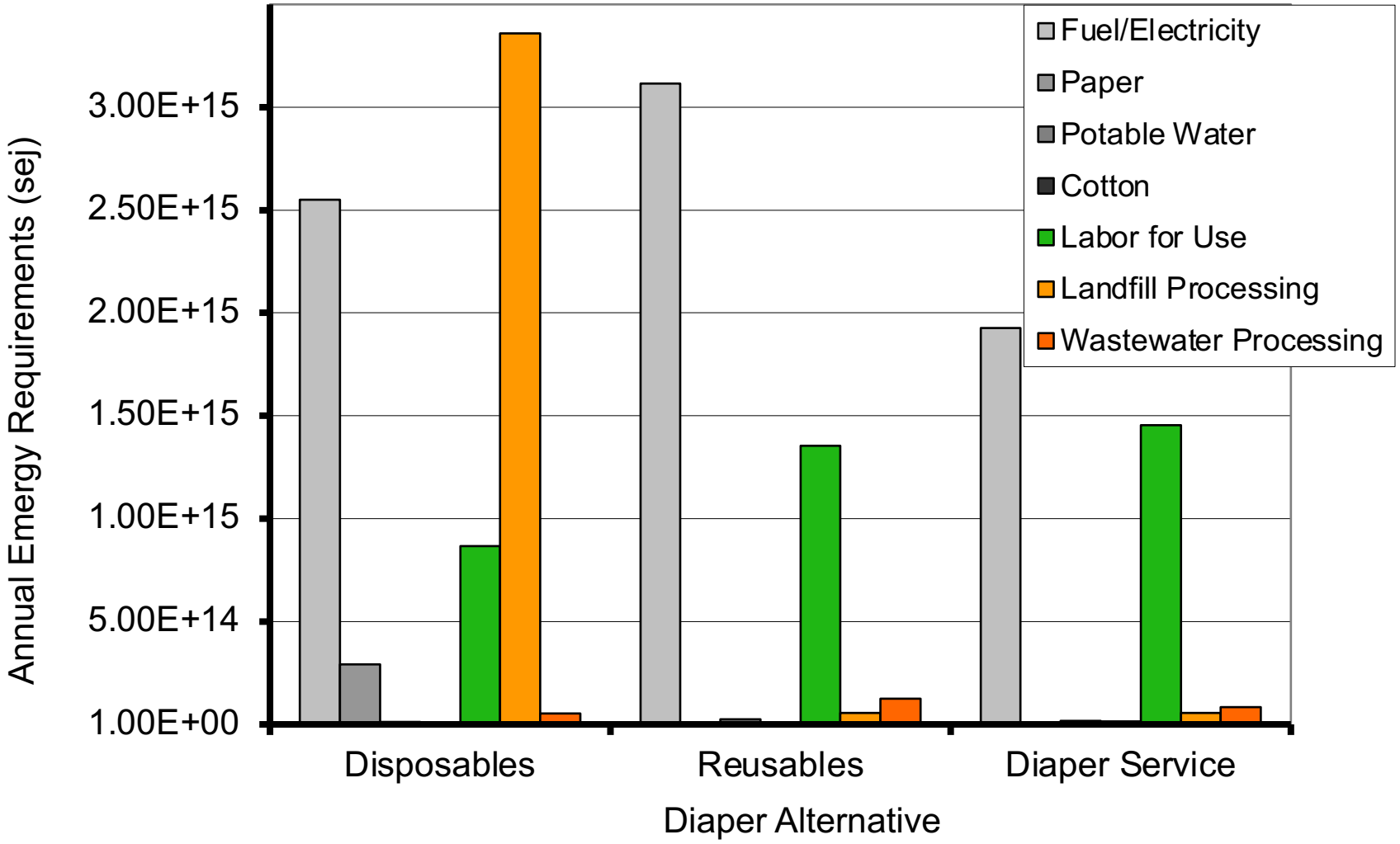
Evaluation of Alternatives...

Evaluation of Diaper Alternatives on a "Per Baby Per Year" Basis

Inputs	Units	Material Flows			UEV	Emergy		
		Disp.	Reus.	Serv.		Disp.	Reus.	Serv.
Fuels/Electricity	GJ	6.22	7.6	4.7	4.1E+05	2.6E+15	3.1E+15	1.9E+15
Potable Water	m^3	21.6	49.7	34	5.0E+11	1.1E+13	2.5E+13	1.7E+13
Processed Cotton	kg	0	2.6	4.2	3.2E+12	0.0E+00	8.4E+12	1.4E+13
Processed Paper Fiber	kg	160	0	0	1.8E+12	2.9E+14	0.0E+00	0.0E+00
Changing Labor	hrs/yr	219	292	292	4.0E+12	8.7E+14	1.2E+15	1.2E+15
Washing Labor	hrs/yr	0	50	75	4.0E+12	0.0E+00	2.0E+14	3.0E+14
Wastewater Processing	m^3	21.6	49.7	34	2.5E+12	5.4E+13	1.2E+14	8.5E+13
Landfill Processing	kg	160	2.6	2.6	2.1E+10	3.4E+15	5.5E+13	5.5E+13
					Total Emergy	**7.1E+15**	**4.7E+15**	**3.6E+15**
					w/out Service	**6.3E+15**	**3.5E+15**	**2.4E+15**

Emergy per Diaper

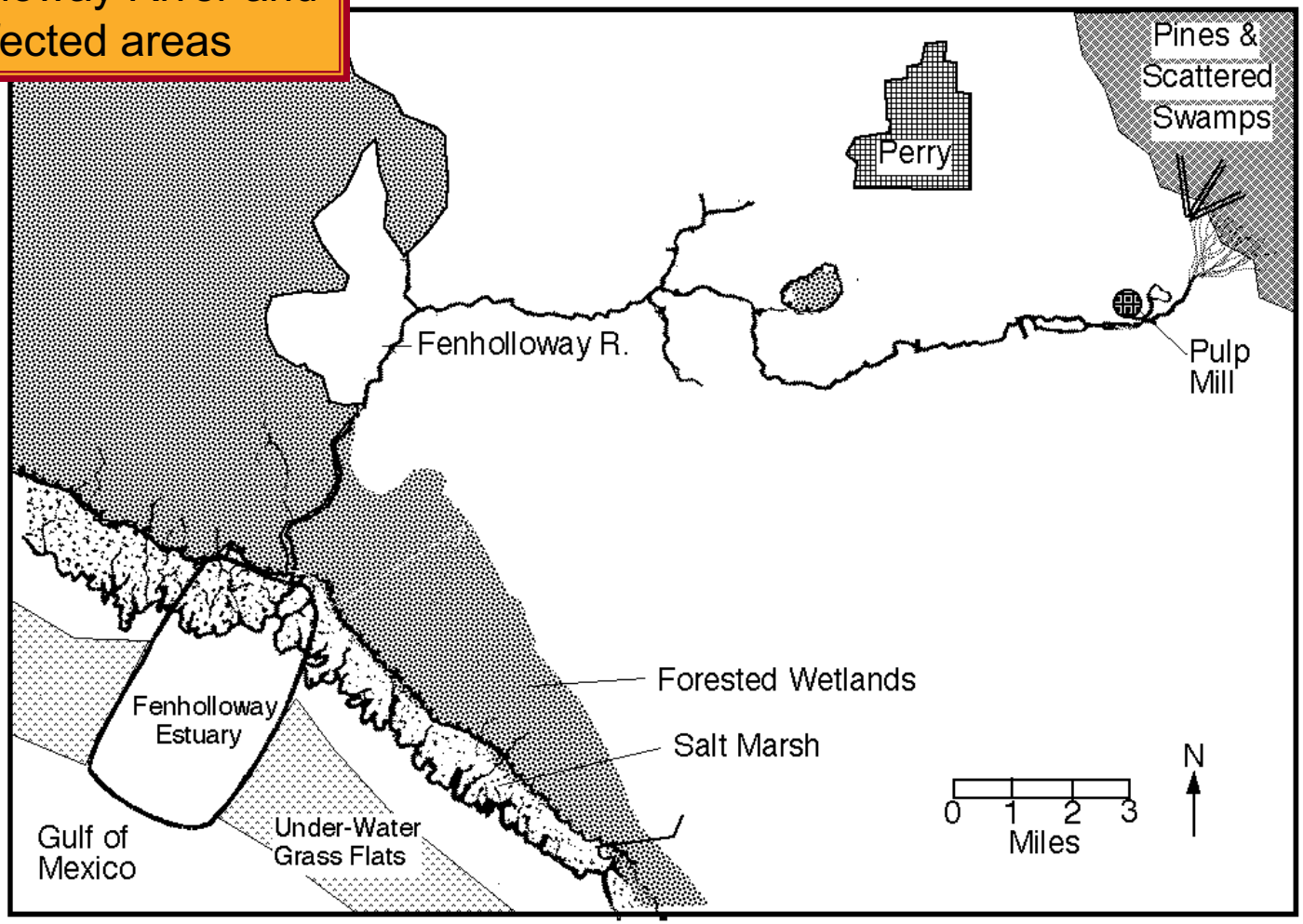
Evaluation of Alternatives...

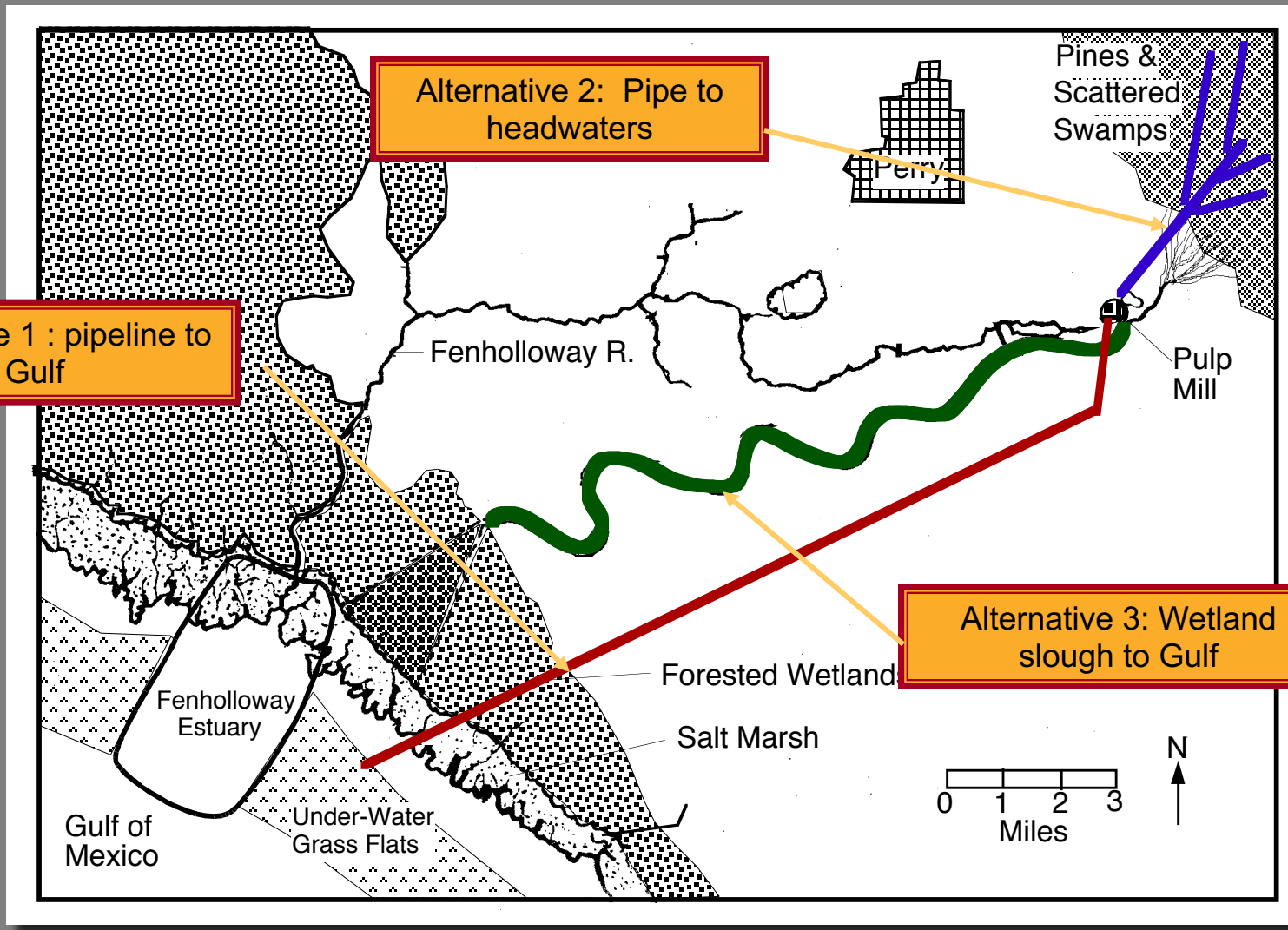


Fenholloway River Restoration

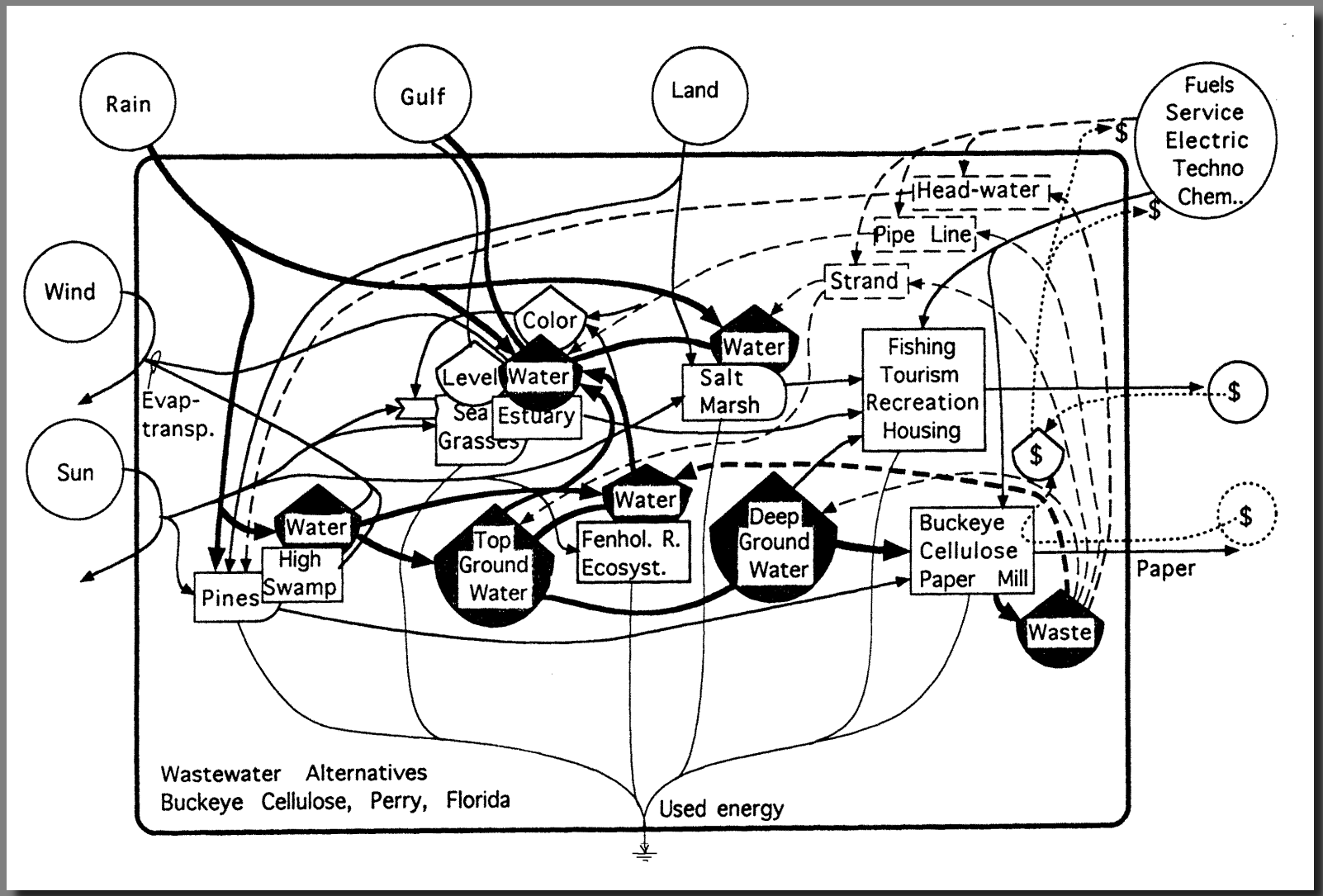
Paper Waste Treatment Alternatives

Study Area showing Fenholloway River and affected areas




Alternative 2: Pipe to headwaters
Alternative 1 : pipeline to Gulf
Alternative 3: Wetland slough to Gulf
Pines & Scattered Swamps
Perry
Fenholloway R.
Pulp Mill
Forested Wetlands
Salt Marsh
Fenholloway Estuary
Gulf of Mexico
Under-Water Grass Flats
0 1 2 3
Miles
N

Alternative waste disposal from paper mill in Taylor County Fl



Emergy Evaluation Table

Table 1 Evaluation of Main Items for Considering waste processing alternatives at Buckeye-Cellulose Pulp Mill Wastes at Perry, Fla. Annual Rates

Note Item	Units	Emergy/unit sej/unit	Emergy E18 sej/yr	Thsd Em$/yr 1995 U.S*
Environmental Systems				
10 Fenholloway River flow without wastewaters				
(a) original 30 cfs	1.34 E14 J	4.8 E4	6.43	4,288
(b) now if no wastes 15 cfs	0.67 E14 J	4.8 E4	3.22	2,144
11 Stream ecosystem metabolism	6.18 E12 J	5.66 E4	0.35	233
12 Distributed water to Headwater				
(a) chemical potential of water	3.46 E14 J	4.8 E4	16.61	11,072
(b) organic load	1.09 E10 J	5.66 E6	0.062	41
13 Headwater wetland production	2.94 E14 J	1.82 E4	5.36	3,567
14 Headwater Pine production	5.76 E14 J	1.82 E4	10.59	6,990
15 Near shore marine processing				
(a) normal grass flats	4.8 E14 J	4 E3	19.2	1,280
(b) present river discharge	1.44 E14	5 E4	7.2	480
16 Salt Marsh Production	--	--	1.27	847
17 Distributing waste waters 14 miles				
(a) cast iron pipe/50 yr	2.8 E8 g	1.074 E9/g	0.30	200
(b) pipe costs	0.54 E6 $	1.5 E12/$	0.81	540
(c) annual operational cost	2.5 E6 $	1.5 E12/$	3.75	2,500
18 Pumping 10 ft uphill: (a) costs	1.8 E5 $	1.5 E12/$	0.27	185
(b) energy	6.48 E12 J	1.7 E5/J	1.10	734

Alternative 1: Pipeline to Gulf

Table 2
Evaluation of Alternative #1, Wastes in Pipeline to the Gulf of Mexico

	Emdollars Million	Costs Millon $
1 Buckeye Plant production	?	?
2 Estuarine Stress	0.78	
3 River Restoration (1/2 flow)	2.1	
4 Water lost from land	11.1	
5 Pipeline prorated over 50 yrs		
a Pipes (Emergy of material)	0.20	
b Cost (services & labor)	0.54	0.54
6 Pipeline operation cost	2.5	2.5
7 Net Benefit: (algebraic sum: +1 +3-2-4-5-6)	- 12.24	
8 Total annual cost		3.04

Alternative 2: Pipe to headwaters

Table 3
Evaluation of Alternative #2 Pumping wastewaters to Headwater Area

	Emdollars Million	Costs Million $
1 Buckeye Plant production	?	?
2 Improved estuary	0.85	
3 Water Retained Inland (with restored river)	11.1	
4 River metbolism restored, natural flow	0.23	
5 organic matter used beneficially	0.041	
6 wetland restored	3.57	
7 Headwater pine production	7.0	
8 Headwater land leasing	1.57	
9 Pipeline prorated over 50 yrs		
a Pipes	0.20	
b cost (services & labor)	0.54	0.54
10 Pipeline operation cost	2.50	2.50
11 Electric power pumping		
a Cost	0.18	0.18
b electric power	0.83	
12 Net Emdollar Benefit (algebraic sum)		
(+1 +2 +3 +4 +5 +6+7-8-9-10-11)	+17.0	
13 Sum of dollar costs		3.22

Alternative 3: Wetland slough to Gulf

Table 4
Evaluation of Alternative #3 Wastes flowing in Wetland Strand

	Emdollars Million	Costs Million $
1 Buckeye Plant production	?	?
2 Improved estuary	0.85	
3 Water used inland and in marsh	11.1	
4 River restored, 1/2 natural flow	2.14	
5 Normalized river metabolism	0.23	
6 Organic matter used in strand and marsh	0.041	
7 Wetland production	0.88	
8 Land leasing	1.59	1.59
9 Strand Construction		
9a excavation	0.58	0.06
9b plantings	0.02	0.02
9c initial clay lining	0.01	0.012
10 Strand management	0.05	0.05
11 Net Benefit: (algebraic sum: (+1 +2 +3 +4 +5 +6 +7 -8-9-10) =	+13.0	
12 Costs		1.73

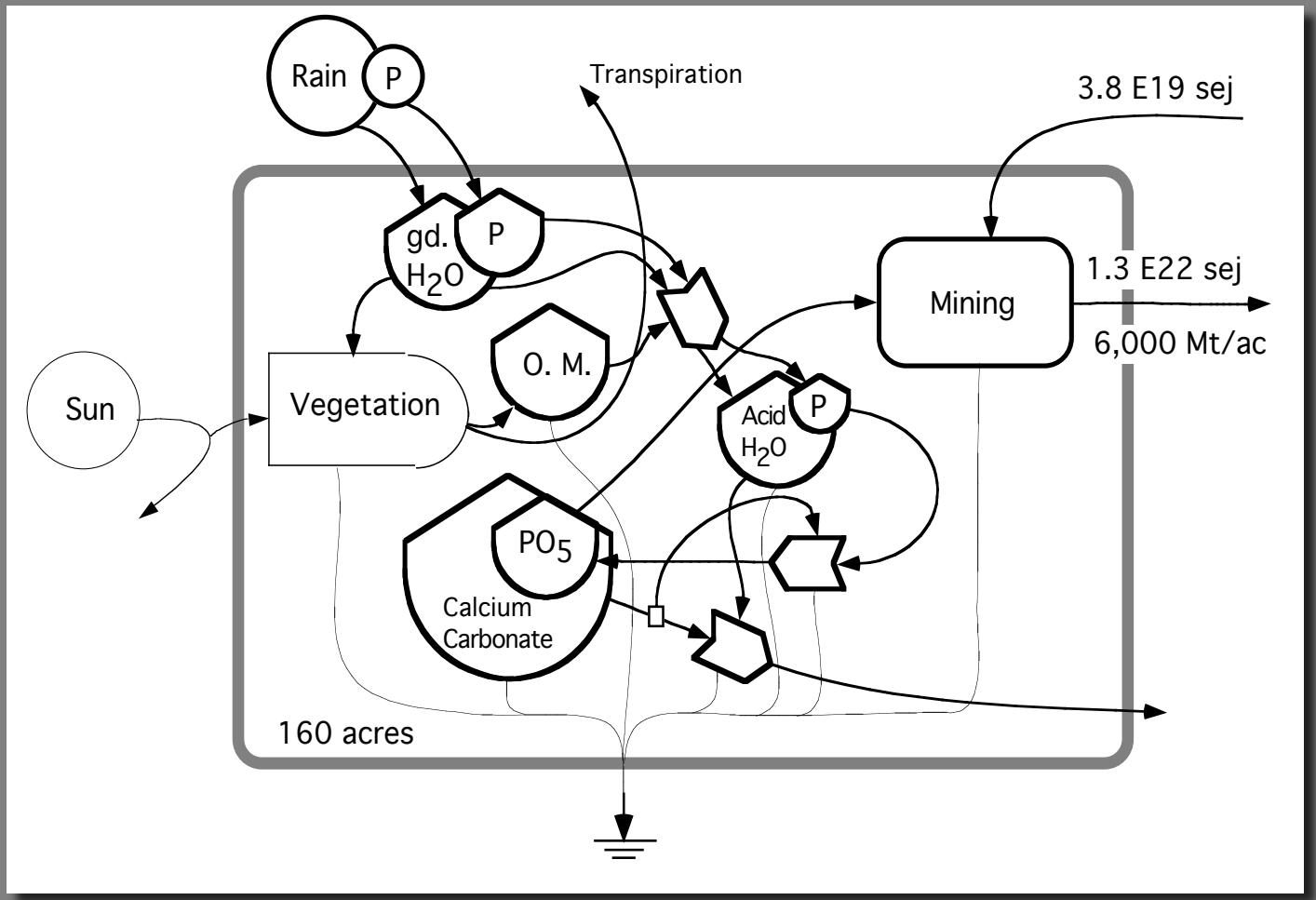
SUMMARY…. Million ^{em}$ per year

Alternative	Empower Benefit* ^{Em}$/yr	Costs $/year	Benefit-Cost ^{Em}$ - $
Fenholloway River, existing	- 15.1	-?	<-15.1
Pipe to estuary	- 13.4	-3.0	-16.4
Recycle uphill into pine lands	+17.0	-4.8	+12.2
Constructed wetland strand	+13.5	-1.7	+11.8

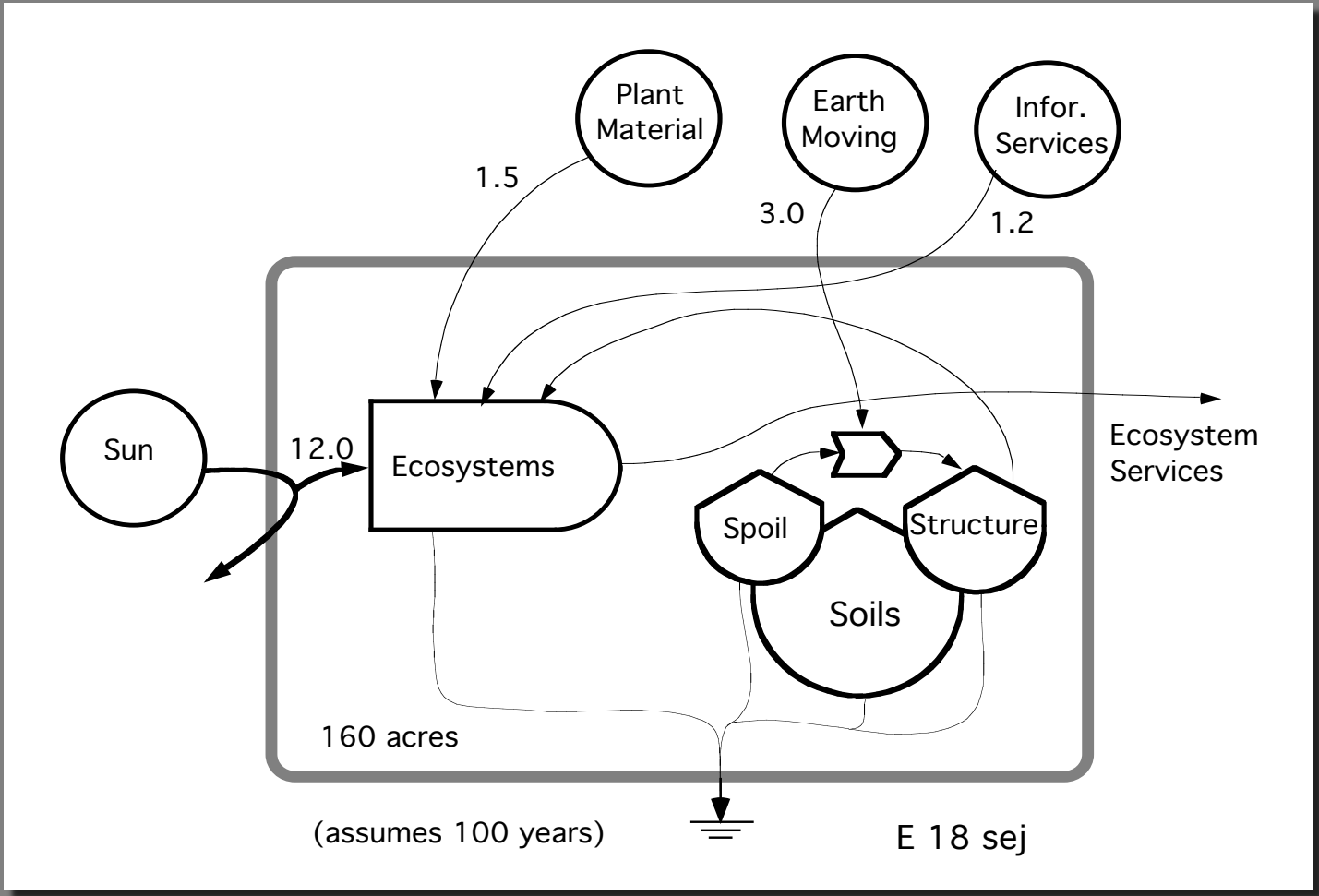
*Emergy increases minus emergy losses

Benefits of Phosphate Mining and Reclamation

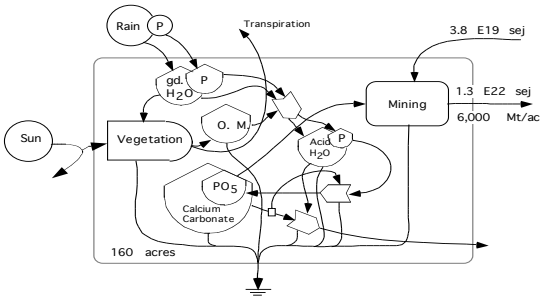
Systems View and Emergy of Mining

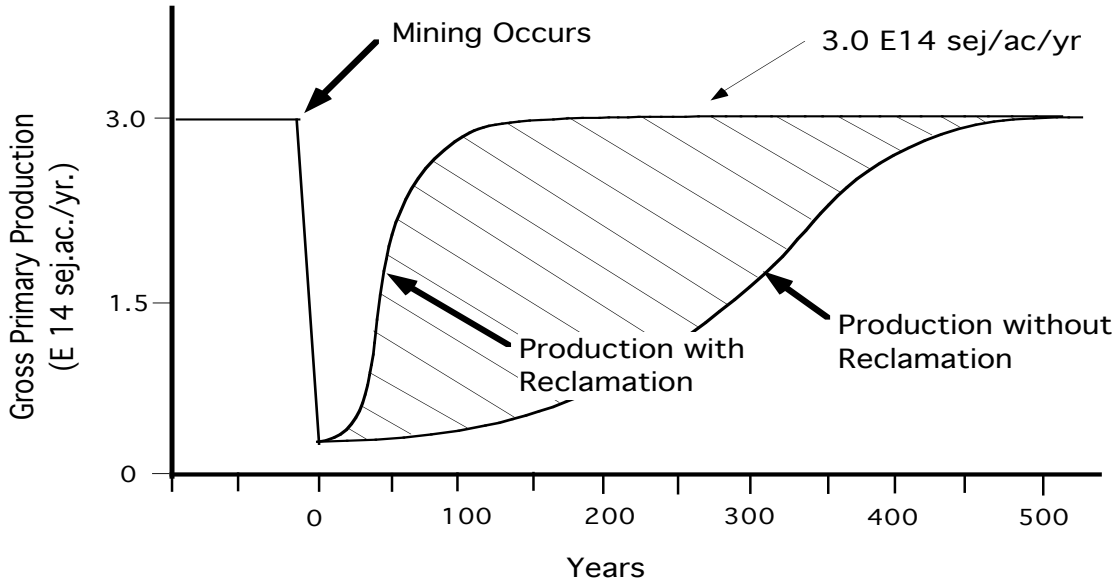


Emergy in Restoration...

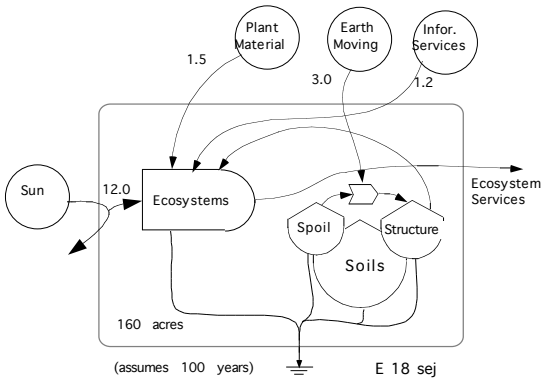


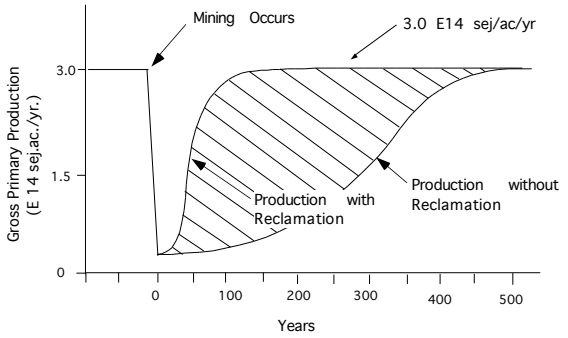
Benefits of Restoration...





Net Benefits Ratio...





Net Benefit of Reclamation:

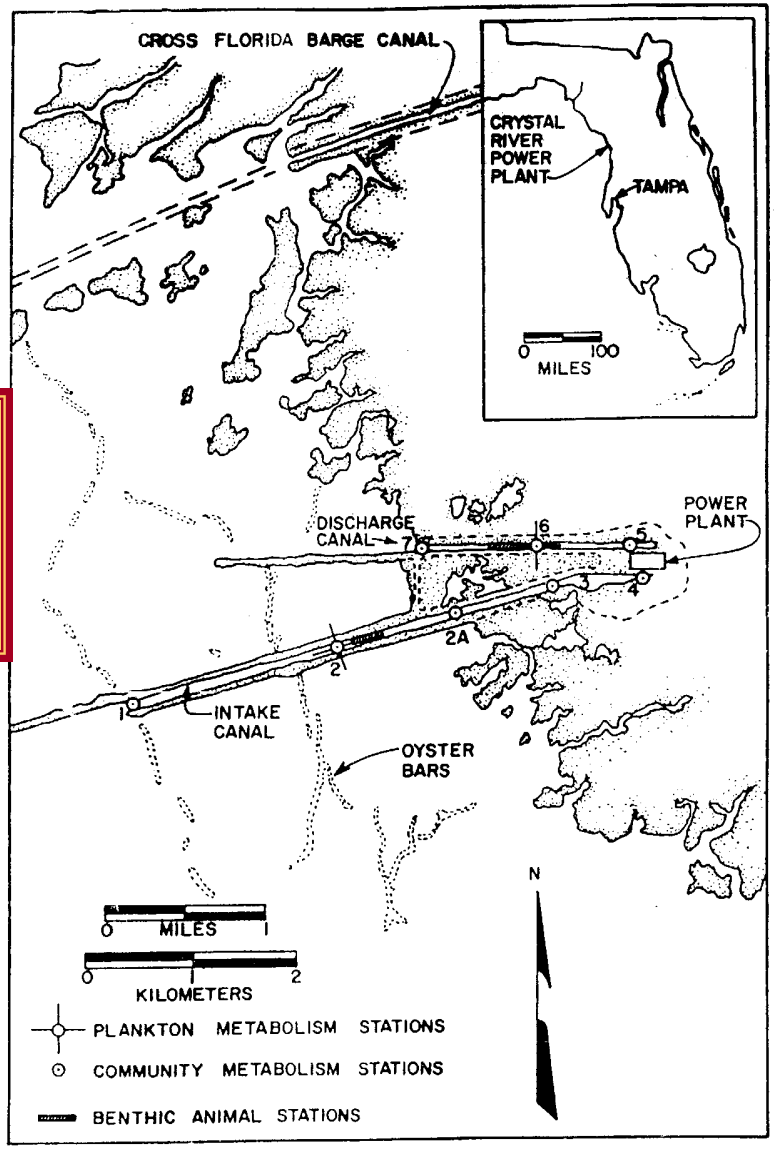
Reclamation costs = 1.5 + 3.0 + 1.2
= 5.7E18 sej

Reclamation benefits = 9.6 E18 sej

Net benefit ratio = 9.6 / 5.7 = 1.68/1

Emergy Evaluation of Power Plant Cooling Alternatives

Map showing the Crystal River Power Plant, estuarine areas and intake and discharge canals.



Summary of emergy evaluation of costs

Crystal River Power Plant

Ecological Costs for Estuarine Cooling

Category	Emergy Cost (E17 sej/yr)
1. Entrainment of zooplankton	6.2
2. Entrainment of juvenile fish	1.1
3. Nekton impingement	0.3
4. Reduce ecological metabolism	1.3
Subtotal	-8.9
5. New canal ecosystem metabolism	1.7
Total	-7.2

Comparison of cooling towers and bay cooling

Crystal River Power Plant

Summary

Emergy Costs:

Estuarine Cooling - 7.2 E17 sej/yr
Cooling Towers - 576.1 E17 sej/yr

Ratio:
576.1/7.2 = **80/1**

Dollar Costs:

Bay Cooling $690,000 / yr
Cooling Tower $17.0 E6 / yr

Ratio:
17.0 E 6 / 6.9 E5 = **25/1**

Summary….

Systems of Value

Market driven values do not belong in the public policy arena

What's the Environment Worth???

It depends on whose paying and for what purpose….

Stewardship, verses outright ownership

Often policy decisions are made by emotion rather than good science…

Thank You...

Questions?