Supplementary Miller Notes – (PJ Shlachtman) Solid and Hazardous Waste

Love Canal Tragedy

- 1942-1953 Hooker Chemicals and Plastics dumped chemical wastes into the love canal
- The company filled the canal and sold it to the Niagara Falls school board warning them not to disturb the clay cap covering the wastes.
- development of the area causes a "bathtub" effect that released harmful contaminates.
- Many health problems resulted.
- The company was sued for damages

Wasting Resources: The high-waste approach

- 33% of solid waste is in the USA
- solid waste: Any unwanted material that is not liquid or gas,
- 75% of solid waste comes from mining and oil/natural gas production.
- Industrial Solid Waste includes: wasted scraps, sludge, fly ash, old machinery
- Remaining 1.5% is Municipal Solid Waste- from homes and businesses in urban areas
- Often the disposal of this waste often goes unchecked

What is hazardous waste, and how much is produced?

- Includes**: (**categories designated by Resource, Conservation and Recovery Act of 1976)
  1) contains one or more of the 39 toxic, etc. compounds.
  2) caustic.
  3) flammable.
  4) is reactive enough to explode or pollute the air with its fumes.
- Does not include:
  1) Radioactive wastes
  2) Hazardous wastes discarded by households
  3) Mining wastes
  4) Waste from small businesses and factories
- 5.5 billion metric tons of hazardous waste are disposed of each year
- 6% is legal hazardous waste
- 94% is unregulated waste

Producing Less Waste and Pollution: Reducing Throughput

What are the options?

1) High-waste approach - Burying, burning, or shipping hazardous waste to another country/county.
2) Low-waste approach - Views waste as a potential resource: Recycle, compost, or reuse. Also try to avoid contributing to the amount of hazardous waste

- Goals:
  1. Reduce
  2. Reuse
  3. Recycle and compost
  4. Incinerate
  5. Bury

Why is producing less waste and pollution the best choice?

1) Saves energy and virgin resources
2) Reduce environmental effects of extracting processing, and using resources
3) Improve worker health and safety
4) Decrease pollution control and waste management costs

Pollution Prevention Pays (3p) Program: (3M Corp)

- Redesigned equipment and processes, identified chemical outputs, and recycled or sold them as raw material to other companies
- Saved 750 million in waste disposal

Solutions: How can we reduce waste and pollution?

- Redesign manufacturing processes to be more efficient
- Design products that use less pollution and waste fewer resources in their production
- Redesign manufacturing processes to produce less waste
- Individual reduction of hazardous cleaning products
- Green design and life cycle assessment help develop products that last longer and are easy to repair, reuse, manufacture, compost, or recycle
- Trash taxes- Charging money per bag of trash
- "Pay as you throw away" system is being used in parts of the US.

Reuse

What are the advantages of refillable containers?

- Reuse
  - Extends resource supplies
  - Keeps high-quality matter resources from being reduced to low-quality matter waste
  - Reduces energy use and pollution.
- Reuse of glass bottles has virtually gone away
- Some want the reinstatement of the system because of the money it saves
- Examples of reusable containers include lunchboxes and Tupperware

What kind of bags should you use for groceries?

- Plastic containers degrade slowly.
- Paper bags use trees and pollute the air and water
- Overall paper bags do more environmental damage, and cost more to produce.
- The best kind of bag to use is canvas

What can we do with used tires?

1) 2.5-4 billion used tires are in landfills, old mines, abandoned houses, and other dump sites.
2) Fire hazard
3) Also produces air pollutants and toxic run-off when burned

- **Reuse** by retreading the tires, using for foundations of homes, artificial reefs, walls for highways, or use to produce electricity,
- **Recycle** to make resins to manufacture certain products.

Recycling

How can we recycle organic solid wastes? Community Composting

- **Compost**
  - dark-brown, humus-like material that is rich in organic matter and soil nutrients.
  - produced when microorganisms break down organic matter
  - 35% of municipal solid waste is biodegradable
  - To compost mix unwanted wastes with soil, put the mixture in a pile or container, stir occasionally, and let rot for months.
  - Resulting compost can be used as an organic soil fertilizer, topsoil, landfill cover
  - Also restores eroded soil on hills, highways, strip-mined land, overgrazed land, and eroded cropland.
- You need to control compost in order to be successful. 3 ways**:**
  1) Enclosing the facilities and filtering the air inside.
  2) Creating municipal compost operations near existing landfills
  3) Decomposing biodegradable wastes in a closed metal container

What are the two types of Recycling?

Primary or secondary.

1) **Primary or closed-loop recycling**
   - Wastes from consumers are recycled to create products of the same type.
   - Primary recycling reduces virgin material use by 20-90%
2) **Secondary or open-loop recycling**
   - Waste material is converted into other products.
   - Secondary reduces virgin material use by only 25%

Case Study: Recycling municipal solid waste in the US

- 27% of municipal solid waste was recycled or composted in 1996.
- Many US cities have curbside recycling programs showing a 50-80% recycling rate.
- "Pay as You Throw"- Charge money for amount of non-recycled garbage per family
- Recycling also creates jobs.

Is centralized recycling of mixed solid waste the answer?

- Large scale recycling can be achieved by collecting mixed urban waste and transporting it to centralized **Materials-recovery facilities (MRFs)**
- Machines separate the materials into paper, plastic, etc. from glass and valuable resources which are sold to companies.
- Plastic and paper are burned to use for electricity.
- Negatives:
   - Plants are expensive and difficult to maintain
   - There must be a large input of garbage to outweigh the costs
   - These plants can release toxic air pollutants
   - Create health threats for the workers
   - Odor, Noise, Truck Traffic

Is separating solid wastes for recycling the answer?

- Most solid waste experts say it makes sense for trash to be sorted into reusable and nonusable before it is picked up.
- Many small source separation operations are being squeezed out by large waste management companies operating the material recovery facilities.
- Some government contracts allow the large companies to take the business.
- The aluminum an paper separated from recycling are worth a lot of money, and are sometimes stolen.

Does recycling make economic sense?

Yes and No

- Recycling programs should not be judged on whether they pay for themselves.
- Problems: recycling....
   1. Is almost a religion that is above criticism
   2. Doesn't make sense if cost outweighs putting garbage in a landfill or burning it.
   3. Is often not needed to save landfill space
   4. Makes sense for easily, but plentiful recyclable materials, but does not makes sense for abundant, hard to recycle materials like glass.
- Benefits: recycling...
   1. Does help the economy, health, and environment overall
   2. Been found to make money in cities with high recycling rates
   3. Reduces the use of virgin resources
   4. Reduces throughput of matter and energy resources
   5. Reduces environmental degradation

Why don't we have more Reuse and Recycling?

- Three factors that hinder recycling:
   1) Environmental and health costs are not added to the price of raw materials

2) Resource extracting industries get better tax breaks than recycling companies
3) There is not a big enough market for recycled goods

- The best way to overcome obstacles to recycling is to make recycling cheaper and to make raw materials and waste disposal (non-recyclable) more expensive.

Case studies: Recycling aluminum, wastepaper, and plastics

How much aluminum is being recycled?

- Benefits of Recycling aluminum as opposed to mining:
  - 95% less air pollution
  - 95% less water pollution
  - 95% less energy used
- In 1994 62% of aluminum cans were recycled (only 15% in 1973).

How much wastepaper is recycled?

- Paper is one of the easiest materials to recycle
- In 1996 the US recycled 40% of its waste paper
- **Benefits**: Saves energy, reduces air pollution, water pollution, groundwater contamination, saves water, saves money.

Is it possible to recycle plastics?

- Plastics industry is a leading producer of toxic waste
- Most plastics are nondegradable or take 200-400 years to degrade
- Environmentalists believe that many uses for plastics are unnecessary

Detoxifying, burning, burying, and exporting wastes

How can hazardous waste be detoxified?

- If waste can't be reused and it is toxic, it must be converted into a less toxic form
- Denmark has the best toxic waste detoxification program in the world
- **Bioremediation** - using microorganisms to detoxify
- **Photoremediation** - using plants to remove contaminants

Is burning solid and hazardous waste the answer?

- 15% of municipal solid waste, and 7% of hazardous waste was burned in 150 incinerators
- All incinerators burning hazardous waste pollute the air
- Many incinerators are being shut down
- Japan uses incinerators the most, and consequently have the most air pollution

Is land disposal of solid waste the answer?

- Sanitary landfill
  - 57% of solid waste
  - **benefits**: cheap, easy, reduces air pollution
  - **drawbacks**: groundwater pollution, and gases from anaerobic decomposition

Is land disposal of hazardous wastes the answer?

- Deep Well Disposal
  - pumping waste into layers of rock below
  - aquifers used for groundwater

Surface Impoundment

- ponds and lagoons
- pollute groundwater and air

Is exporting waste the answer?

- Many countries are trying to ban the export of toxic waste
- Companies export waste because it is cheaper than proper disposal

Case studies: Lead, dioxins, and chlorine

How can we reduce exposure to lead?

- High levels of lead blood causes lower IQ, hyperactivity, nervous system impairment, and other disorders.
- Sources: leaded gasoline, lead paint, etc.

How dangerous are dioxins?

- Definition: a family of 75 chlorinated hydrocarbon compounds formed as unwanted by-products in chemical reactions involving chlorine and hydrocarbons.
- TCDD is a dioxin- could cause cancer
- However, a study in 1996 showed that 86% of dioxins produced in the US could be eliminated without economic sacrifice.

What should we do about chlorine?

- Chlorine is used for plastics (manufacturing), solvents, and paper, pulp bleaching
- In so many cases, there are alternatives to chlorine use - but they are more expensive to use.

Hazardous-waste regulation in the US

What is the Resource Conservation and Recovery Act?

- Passed in 1976: Forces EPA to identify and manage disposal of toxic waste, helps states establish waste management programs.
- However, most producers of hazardous waste are able to get away with illegal dumping.

What is the Superfund Act?

- 1980: Comprehensive Environmental Response, Compensation and Liability Act- Cleans up abandoned dumping sites.
- This act forces the polluter to pay in many cases
- The government still has to pay billions in disaster

Solutions: Achieving a Low-waste society

What is the role of Grassroots action? Bottom-up change

- Everyone can help to stop pollution if they oppose: Polluters, hazardous waste landfills, wells, incinerators, and exports

How can we make the transition to a lower-waste society?

- The Principals:
  1) Everything is connected
  2) There is no “Away”
  3) Dilution is not the solution (to pollution)
  4) Prevention and recycling is the cheapest way to deal with pollution

CH. 20 - Pesticides and Pest Control

Chapter Objectives:

1. List the five types of pesticides and what they are used to treat.

2. Briefly describe the history of the development of pesticides.

3. List five common household pests and two ways to control them other than using pesticides.

4. List the five major classes of pesticides. Tell if each is broad spectrum or narrow spectrum; state its degree of persistence; give two examples; and tell if each undergoes bioaccumulation or is biologically magnified.

5. Compare contact and systemic herbicides.

6. Give seven reasons to use pesticides. List five characteristics of the ideal pesticide.

7. Describe the consequences of relying heavily on pesticides. Describe the pesticide treadmill. Be sure to describe biological magnification. Briefly describe the threat of pesticides to wildlife and human health.

8. Name the U.S. law that controls pesticide regulation. Give three reasons why this law is considered the weakest and most poorly enforced of the environmental laws. Summarize how the 1996 Food Quality Protection Act extends this law.

9. List and briefly describe nine alternative pest management strategies.

10. Define *integrated pest management*. Analyze the pros and cons of using IPM. List six steps that could be taken to help promote IPM.

Types of Pesticides and Their Uses

- **Pests:** Any species that competes with us for food, invades lawns and gardens, destroys wood in houses, spreads disease, or is a nuisance.
- **Pesticides:** (Biocides) Chemicals developed to kill organisms that we consider undesirable.
    1. Insecticides - Insect-killers
    2. Herbicides - Weed-killers
    3. Fungicides – Fungus-killers
    4. Nematocides – Roundworm-killers
    5. Rodenticides – Rat- and Mouse-killers

Plants have been producing chemicals to ward off herbivorous predators for ~225 million years. As herbivores adapt, so they don't starve, plants adapt so that they survive. This is an example of co-evolution.

The First Generation of Pesticides:

1. Sulfur – used as an insecticide since 500 BC
2. Arsenic (As), lead (Pb) and mercury (Hg) by the 1400's
3. Nicotine sulfate – extracted from tobacco leaves in the 1600s
4. Pyrethrum – obtained from the heads of chrysanthemum flowers
5. Rotenone – from the root of the derris plant

The Second Generation of Pesticides:

- About 2.5 million tons of pesticides are used yearly, worldwide. In the United States, about 630 different biologically active (pest-killing) ingredients and 1,820 inert (inactive) ingredients are mixed to make 25,000 different pesticide products.
    1. DDT – 1939, Entomologist Paul Mueller discovered that DDT (dichlorodiphenyltrichloroethane) was a potent insecticide. It soon became the world's most-used pesticide. Awarded a Nobel Prize in 1948.
    2. Broad-spectrum agents – toxic to many species
    3. Selective-spectrum agents – effective against a narrowly defined group of organisms.
- Since 1950 pesticide usage has increased 50 fold and toxicities have increased 10 fold.
- 10X more synthetic pesticides are used on the average home than on croplands in the US.

- ~75% of synthetic pesticides are used in the developed countries

1. **Persistence** – the length of time in which pesticides remain deadly in the environment; this may vary from days to years.
2. **Biomagnification –** the process by which toxins accumulate the higher you go in the food chain (generally because the toxin is not water soluble and therefore not easily excreted).

The Case For Pesticides:

1. **Pesticides save human lives:** Since 1945 DDT and other insecticides have probably prevented the premature deaths of at least 7 million people from insect-transmitted diseases.
2. **Pesticides increase food supplies and lower food costs:** About 55% of the world's potential human food supply is lost to pests pre or post harvest. Without pesticides, these losses would be worse, and could cause the prices of food in the U.S. to rise nearly 50%.
3. **Pesticides increase profits for farmers:** Overall, for every dollar spent on pesticides, there is an increase in U.S. crop yields worth approximately $4 for every $1 spent, this decreases to $2 for every $1 if environmental impacts are included.
4. **Pesticides work faster and better than alternatives:** Pesticides can control most pest quickly and at a reasonable cost, can use more if resistance occurs.
5. **The benefits overpower the health risks:** Safer and more effective pesticides are being developed. There is a greater use of botanicals and microbotanicals.
6. Genetically modified pest resistant crops are being developed.

The Case Against Pesticides:

1. **Genetic resistance** – Insects can develop immunities to pesticides in just a few years (5 – 10) through directional selection. Weeds and plants develop genetic resistance much more slowly.
2. **Broad-spectrum insecticides kill good organisms** – This includes killing natural predators and parasites that may have been maintaining the population of a pest species at a reasonable level.
3. **Pest Upset** – Wiping out natural predators and parasites can also unleash new pests whose populations the predators had previously held in check, causing other unexpected effects.
4. **Pest Resurgence** – natural predators and parasites are killed and pest population rebounds resistant to current pesticide and without natural predators.
5. **Circle of Poison** – banned pesticides are used on food crops outside of the US, the US imports these food crops and bring the pesticide back to the US.

- **The Pesticide Treadmill:** A situation where farmers are forced to pay more for a pest control program that often becomes less effective as genetic resistance develops.
- Although the use of synthetic pesticides has increased 33-fold since 1942, it is estimated that more of the U.S. food supply is lost to pests today than in the 1940s. Losses due to insects have doubled even though insecticide use has increased 10 fold.
- The estimated environmental, health, and social costs of pesticide use in the United States range from $4 billion to $10 billion per year.
- Alternative pest control practices could halve the use of chemical pesticides on 40 major U.S. crops without reducing crop yields.
- A 50% cut in U.S. pesticide use would cause retail prices to rise by only about .2% but would raise average income for farmers about 9%.

Where Do Pesticides Go?

Environmental Effects:

- Less than 2% of the insecticides applied to crops by aerial spraying or by ground spraying actually reach the target pests, less than5% of herbicides reach their intended weed targets.
- **Pesticide Mobility –** pesticides travel → through the air, surface and groundwater, bottom sediments

- **Biomagnification** - Some pesticides can harm wildlife – DDT had harmful effects in the environment when it biologically magnified in food webs. This resulted in certain birds being listed on the endangered species list in the U.S. because of fatal effects.
- Each year 20% of honeybee colonies in the U.S. are wiped out by pesticides, while another 15% are damaged, costing farmers over $200 million annually.
- More than 67 million birds and 6 –14 million fish are killed annually due to pesticides

Human Health:

- An estimated 25 million agricultural workers in developing countries are seriously poisoned by pesticides each year. 220,000 deaths result.
- In developed countries an estimated 300,000 farm workers suffer from pesticide-related illnesses yearly. 250,000 Americans get sick each year from home use / misuse of pesticides. This may be an underestimate due to poor record keeping and inaccurate diagnoses.
- Approximately 13% of vegetables and fruits consumed in the United States may contain illegal pesticides and levels of approved pesticides above their legally allowed limits.
- At least 75% of the active ingredients approved for use in U.S. pesticide products cause cancer in test animals.
- According to the EPA, 165 active ingredients are know or suspected human carcinogens, and to date, only 41 have been banned or voluntarily discontinued.
- Concern about genetic mutations, birth defects, impacts on the nervous, immune and endocrine systems.

Pesticide Regulation In The United States:

FIFRA – Federal Insecticide, Fungicide and Rodenticide Act

- Passed in1947, amended 1972
- All commercial pesticides must be approved by the EPA for general or restricted use
- When a pesticide is legally approved for use of fruits or vegetables, the EPA sets a tolerance level, which specifies the amount of toxic pesticide residue that can legally remain on the crop when the consumer eats it.
- Between 1972 – 2001 – banned or severely restricted 56 active ingredients
- EPA ordered all pre 1972 ingredients to be re evaluated; as of 2002 only ~10% of the 600 ingredients had been re evaluated.
- According the a National Academy of Sciences study, federal laws regulating the use of pesticides in the United States are inadequate and poorly enforced by the EPA, FDA, and USDA.
- Exposure to pesticide residues in food causes 4,000-20,000 cases of cancer per year in the United States.
- A 1993 study of pesticide safety by the U.S. National Academy of Sciences urged the government to do the following things:
  - Make human health the primary consideration for setting limits of pesticide levels allowed in food.
  - Collect more and better data on exposure to pesticides for different groups, including farm workers, adults, and children.
  - Develop new and better test procedures for evaluating the toxicity of pesticides, especially for children.
  - Consider cumulative exposures of all pesticides in food and water, especially for children, instead of basing regulations on exposure to a single pesticide.

Progress made with the passage of the 1996 Food Quality Protection Act:

- Requires new standards for pesticide tolerance levels in foods, based on a reasonable certainty of no harm to human health.
- Requires manufacturers to demonstrate that the active ingredients in their pesticide products are safe for infants and children.
- Allows to EPA to apply an additional 10-fold safety factor to pesticide tolerance levels to protect infants and children.

- Requires the EPA to consider exposure to more than one pesticide when setting pesticide tolerance levels.
- Requires the EPA to develop rules for a program to screen all active and inactive ingredients for their estrogenic and endocrine effects by 1999. (As of Dec. 2002 this has not been achieved)

Solutions:

Economic Threshold – when economic losses caused by pest damage outweigh the cost of applying pesticides.

How Can Cultivation Practices Control Pests:

- Crop rotation
- Planting rows of hedges or trees around fields to hinder insect invasions.
- Adjusting planting times so that major insect pests either starve or get eaten by their natural predators.
- Planting trap crops to lure pests away from the main crop.
- Increase the use of polycultures (as opposed to monocultures)
- Grow crops where major pests don't exist

How Can Genetically Resistant Plants Help Lower Pest Losses:

- Plants and animals that are genetically resistant to certain pests - insects, fungi, and diseases can be developed.
- Use genetic engineering to build pest and disease resistance into crops and thus reduce the need for pesticides.

Using Natural Enemies to Help Control Pests – Biological Control

- Use natural predators, parasites, and pathogens to regulate pest populations.
- Pros
    - Species specific
    - Saves ~$25 for every $1 invested (in the US)
    - Nigeria – used a parasitic wasp to fight the cassava mealy worm – Saved $178 for every $1 invested
    - Difficult to develop genetic resistance
- Cons
    - Can't always be mass produced
    - May be slower acting
    - May be killed off by pesticides from adjacent fields (as a result of pesticide mobility)

Insect Birth Control, Sex Attractants, and Hormones:

- Sterile Male Technique - Males of some insect pest species can be raised in the laboratory, sterilized by radiation or chemicals, and then released into an infested area to mate unsuccessfully with fertile wild animals. Has been used on the screwworm fly and the Mediterranean fruit fly.
- Pheremones – sex attractants – bait traps and capture males
- Juvenile hormones, molting hormones – halt metamorphosis – prevent maturation and reproduction

Alternate Methods

- **Hot Water:** The 'Aqua Heat' Machine sprays boiling water on crops to kill weeds and insects. Has been used on cotton, alfalfa, potatoes and citrus plants (wouldn't be effective in a rice paddie)
- **Radiation:** Exposing certain foods after harvest to gamma rays emitted by radioactive isotopes will extend food shelf life and kill harmful insects, parasitic worms, and bacteria.

Integrated Pest Management (IPM): In this approach, each crop and its pests are evaluated as parts of an ecological system. Then a control program is developed that includes a mix of cultivation and biological and chemical methods applied in proper sequence with the proper timing.

- The overall goal is not to eliminate pest populations, but reduce crop damage to an economically tolerable level.
- IPM requires expert knowledge about each pest situation, and is much slower acting then conventional pesticides.
- At times, more labor intensive
- Although long-term costs are typically lower than the costs of using conventional pesticides, initial costs may be higher.
- Can reduce pesticide usage and control costs by 50 – 90%
- Reduce pre harvest losses by 50%
- Improve crop yield (Indonesia → reduced pesticide usage by 65%, increased rice yields by 15%)
- Reduce fertilizer and irrigation inputs
- Hindered by government subsidies and opposition from agricultural chemical companies
- In a 1996 NAS study, Scientists urge the USDA to promote IPM in the U.S. by:

i) Adding a 2% sales tax on pesticides and using revenue to fund IPM research and education.

ii) Setting up a federally supported IPM demonstration project on at least one farm in every county.

iii) Training USDA field personnel and county farm agents in IPM so that they can help farmers use this alternative.

iv) Providing federal and state subsidies to farmers who use IPM.

v) Gradually phasing out subsidies to farmers who depend almost entirely on pesticides, once effective IPM methods have been developed for major pest species.