ehp

LESSON:

Arsenic and Lead Scavenger Hunt

Summary: Students read an article about residential land being contaminated with lead and arsenic from use of pesticides. Then they develop a sampling plan to determine if a residential property and community park might be contaminated with lead/arsenic.

Lesson Type: Extension—This lesson extends a topic in the *EHP Student Edition* article.

***EHP* Article:** "The Apple Bites Back: Claiming Old Orchards for Residential Development"
EHP Student Edition, November 2006, p. A470–A476
http://www.ehponline.org/docs/2006/114-8/focus-abs.html

Objectives: By the end of this lesson, students should be able to

1. describe land use hazards associated with orchards;
2. classify land according to its common use; and
3. create a soil sampling plan to evaluate sites potentially contaminated with arsenic/lead.

Class Time: 60–75 minutes

Grade Level: 9–12

Subjects Addressed: Environmental Sciences, General Science

Prepping the Lesson (15 minutes)

INSTRUCTIONS:

1. Download the entire November 2006 *EHP Student Edition*, or download just the article "The Apple Bites Back: Claiming Old Orchards for Residential Development" at http://www.ehponline.org/docs/2006/114-8/focus-abs.html.

2. Review the Background Information, Instructions, and Student Instructions.

3. Read the article "The Apple Bites Back: Claiming Old Orchards for Residential Development."

4. Review the two Reference articles on soil sampling at http://www.ecy.wa.gov/pubs/0309037.pdf and http://www.ecy.wa.gov/pubs/0309044.pdf.

5. Decide how you want to group students and assign each group one area plan (residential property or community park) for which to create a soil sample.

6. Make copies of the *EHP Student Edition* article, Student Instructions, and Worksheets as necessary.

MATERIALS (per student):

- 1 copy of *EHP Student Edition*, November 2006, or 1 copy of the article "The Apple Bites Back: Claiming Old Orchards for Residential Development"
- 1 copy of the Student Instructions

VOCABULARY:

- composite sampling
- hot spot
- lead arsenate
- pathways of exposure
- pooled
- representative
- sampling
- uniquely vulnerable individual

BACKGROUND INFORMATION:

Land and property may have become contaminated with hazardous substances because of historical practices that were not regulated or recognized as threats to human health at the time the contamination occurred. The *EHP Student Edition* article "The Apple Bites Back: Claiming Old Orchards for Residential Development" discusses the use of lead arsenate as a pesticide in orchards in the first 50 years of the twentieth century. Since lead and arsenic are extremely persistent in the soil, they continue to pose potential health problems, especially if the orchard lands are converted to other land uses, such as playgrounds or housing developments. When land and property changes uses (e.g., from agricultural to residential, or from industrial to residential), the site should be evaluated for historical contamination to protect future users of the land and property. A Phase 1 Environmental Site Assessment involves a historical review of the site and the potential for contamination. A Phase 2 Environmental Site Assessment involves soil sampling to determine the presence of any contaminants.

Homeowners and community residents may become concerned about past contamination and request soil sampling to verify if the contaminants are present above safe levels. The U.S. Environmental Protection Agency (EPA) has established soil concentrations above 400 ppm for lead and 0.4 ppm for arsenic as the criteria for residential soil cleanup. However, state criteria for cleaning up residential areas varies from state to state ranging from 50 to 500 ppm for lead and 0.4 to 31 ppm for arsenic. Arsenic state cleanup criteria are often set higher than federal criteria to address high levels of naturally occurring arsenic in the soil.

Guidance to help homeowners and community residents assess the risk of lead and arsenic contamination has been developed by some state agencies. Individuals concerned about possible contamination should contact their state departments of environmental protection for guidance. The following questions are often asked by residents: what contaminates may be present, what are the health risks, when to sample, where to sample, how to sample, how to analyze the samples, what do the sample results mean, and what remediation actions should I take. This lesson explores the science of where to sample, and uses two publications developed by the Washington State Department of Ecology (1993a & b). Area plans used by the lesson are taken directly from these publications with the permission of the Washington State Department of Ecology.

References:

Washington State Department of Ecology. 1993. Child Use Area: Arsenic and Lead Soil Sampling Guidance (#03-09-037). Olympia, WA: Washington State Department of Ecology. Available: http://www.ecy.wa.gov/pubs/0309037.pdf.

Washington State Department of Ecology. 1993. Residential Property: Arsenic and Lead Soil Sampling Guidance (#03-09-044). Olympia, WA: Washington State Department of Ecology. Available: ww.ecy.wa.gov/pubs/0309044.pdf.

RESOURCES:

Environmental Health Perspectives, Environews by Topic page, http://ehp.niehs.nih.gov. Choose Arsenic, Lead

Agency for Toxic Substances and Disease Registry, ToxFAQs™ for arsenic, http://www.atsdr.cdc.gov/tfacts2.html

Agency for Toxic Substances and Disease Registry, ToxFAQs™ for lead, http://www.atsdr.cdc.gov/tfacts13.html

Environmental Protection Agency, Preparation of soil sampling protocols: sampling techniques and strategies, http://www.ecy.wa.gov/pubs/0309044.pdf

New Jersey Department of Environmental Protection, Historic pesticide contamination: information for home owners, home buyers and other members of the public, http://www.state.nj.us/dep/special/hpctf/pestfact.pdf

New Jersey Department of Environmental Protection, Findings and recommendations for the remediation of historic pesticide contamination, http://www.state.nj.us/dep/special/hpctf/final/hpctf99.pdf

Washington State Department of Ecology, On-line guide for homeowners and small businesses: what to do if you discover toxic waste on your property, http://www.ecy.wa.gov/programs/tcp/olga/olg_faq_pg.htm

Implementing the Lesson

INSTRUCTIONS:

1. Tell students they are going to learn about historical contamination of property caused by treating orchards with pesticides.
2. Divide students into groups and pass out the Student Instructions and a copy of the article "The Apple Bites Back: Claiming Old Orchards for Residential Development." Have students complete the activity.
3. As a group discuss the students' answers to the Step 1 questions. Then have each group report and defend their sampling plan to the whole class.
4. Provide each group with a copy of the community park or residential property area plan and instruct them to complete the remaining Steps (2–4).

NOTES & HELPFUL HINTS:

1. The sampling plans reported in this lesson do not address possible lead contamination from lead-based paint. If lead-based paint was a concern, additional soil samples would be needed in close proximity to any building and along the building perimeter.
2. An overhead of the area plans can be made for each group. Have each group use their overhead when they present and defend their sampling plans.
3. You may consider giving the students a reasonable hypothetical budget to work within. For example, a homeowners' association may be able to provide $1,000–3,000 for sampling.

Aligning with Standards

SKILLS USED OR DEVELOPED:

- Classification
- Communication (note-taking, oral, written)
- Comprehension (listening, reading)
- Critical thinking and response
- Technological design

SPECIFIC CONTENT ADDRESSED:

- Environmental health
- Pesticide contamination
- Sampling strategies

NATIONAL SCIENCE EDUCATION STANDARDS MET:

Science Content Standards

Unifying Concepts and Processes Standard

- Systems, order, and organization
- Evidence, models, and explanation
- Constance, change, and measurement
- Evolution and equilibrium
- Form and function

Science as Inquiry Standard

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Physical Science Standard

- Structure of atoms
- Structure and properties of matter
- Chemical reactions

Science and Technology Standard

- Abilities of technological design
- Understandings about science and technology

Science in Personal and Social Perspectives Standard

- Personal and community health
- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

History and Nature of Science Standard

- Nature of scientific knowledge
- Historical perspectives

Assessing the Lesson

Step 1: a. What are the sources of lead and arsenic found in soil?

Pesticides (lead arsenate, copper acetoarsenite, and calcium arsenate); natural background. Other sources not mentioned in the article: lead-based paint, leaded gasoline, and industrial contamination (e.g., smelters and lead battery manufacturing and recycling).

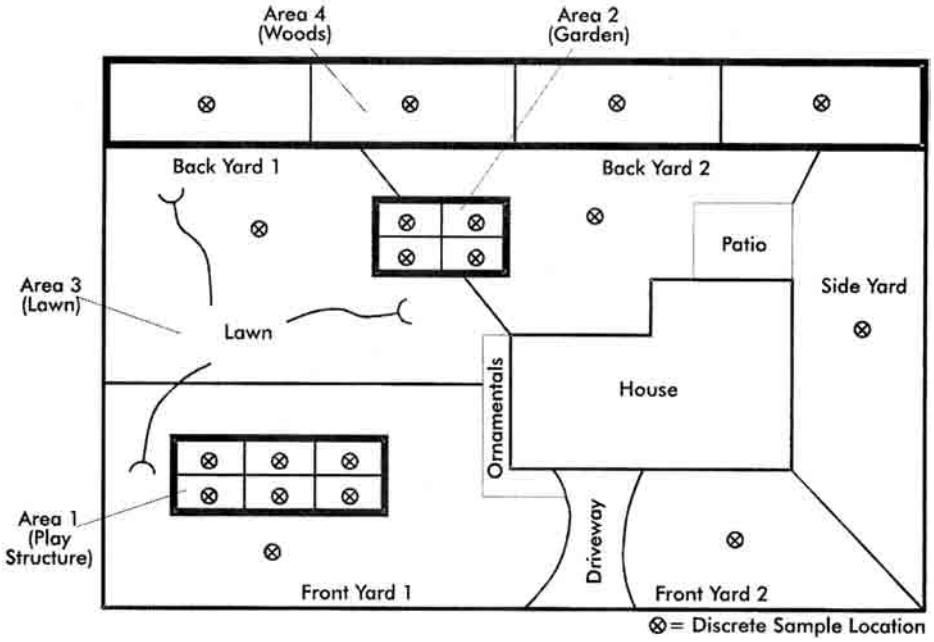
b. What are the health effects of exposure to lead and arsenic in soil?

Arsenic: human carcinogen; lead: neurological damage, especially prenatally and childhood. Risks to health from soil exposure are low, but increase significantly when the contamination moves into the water supply.

Step 3: b. How many samples did you collect?

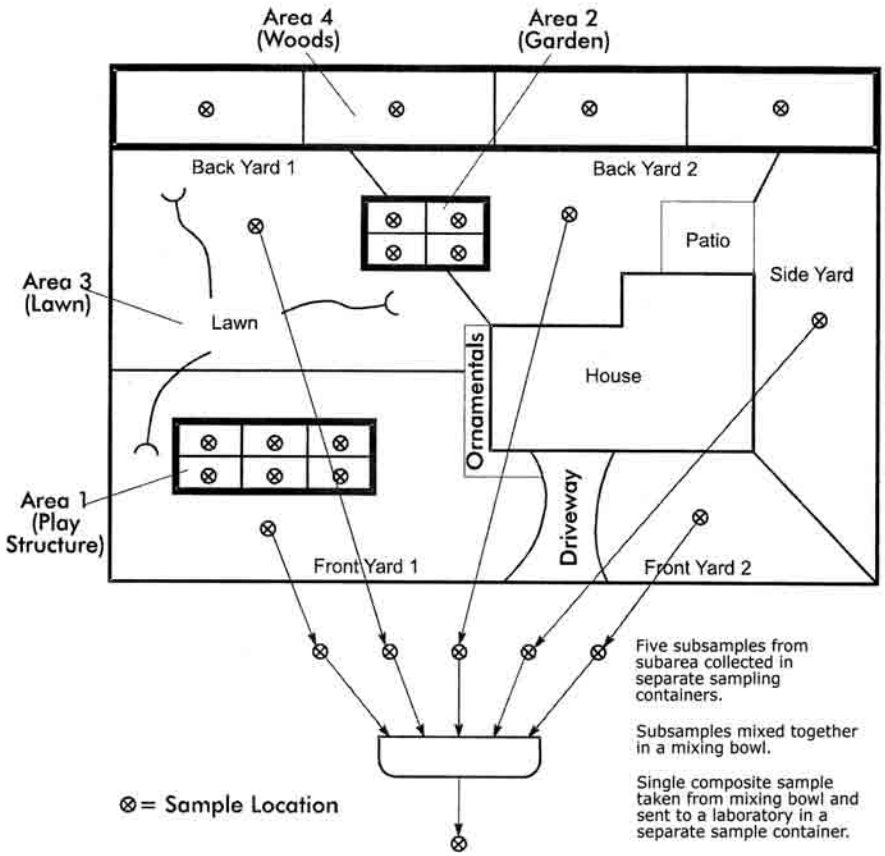
Responses will vary. The following suggested numbers and locations of samples using single and composite samples were developed by the Washington State Department of Ecology (SA=sampling area):

Residential Property—Suggested Number (19) and Locations of Samples

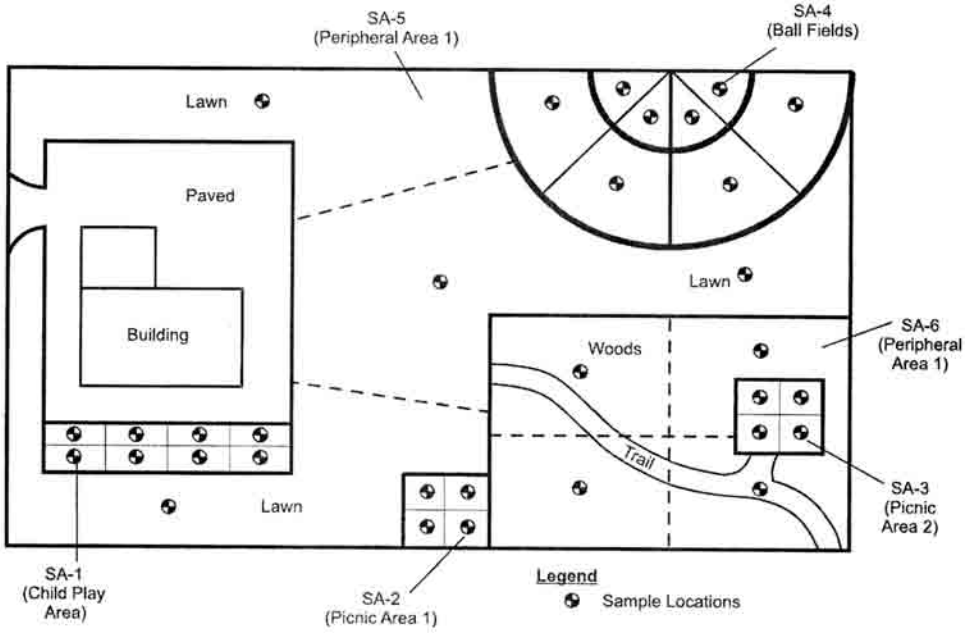


Note: samples in the woods might have also been combined as a composite sample to further reduce costs.

Residential Property—Suggested Number (15) and Locations of Samples with Composite Samples

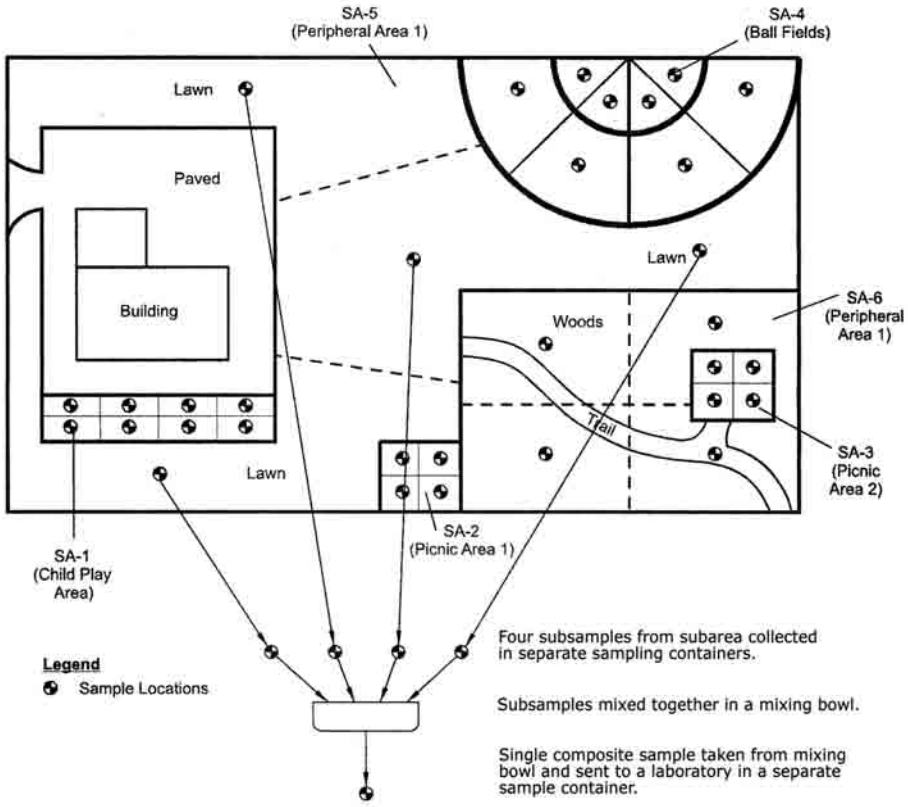


- **Community Park—Suggested Number (32) and Locations of Samples**



National Institute of Environmental Health Sciences
Community Outreach & Education Program

Community Park—Suggested Number (29) and Locations of Samples with Composite Samples



c. What was the total cost of implementing your sampling plan?

Responses will vary. The following suggested costs using single and composite samples were developed by the Washington State Department of Ecology:

- Residential property—single samples ($950)
- Residential property—composite samples ($750)
- Community park—single samples ($1,600)
- Community park—composite samples ($1,450)

d. Explain the strategy you used to decide where to collect the samples.

Responses will vary. Any sampling strategy that adequately considers the criteria outlined in Step 2 of the Student Instructions is acceptable. The suggested sampling plans follow all of the criteria. Areas of similar use and character are grouped (woods, yard, child play area, play structure, garden, lawn, ball fields, picnic area). All grouped or stratified areas have at least four samples. Areas of special concern where there is greater potential for exposure to humans (child play area, play structure, ball fields, garden, picnic area) are sampled more frequently and more intensively. Children represent a special high-risk population, and areas they may come in contact with (child play area, play structure, ball fields) are sampled more intensively. Grouped areas are systematically sampled in defined grid patterns to ensure broad and even sampling coverage. Composite samples are selected from grouped areas representing areas of lower risk (e.g., lawns because they are covered with grass). Areas that pose minimal risk because the ground is permanently covered (e.g., driveways, paved areas, patios) are not sampled.

Discuss the following scenarios with students regarding factors to consider in their sampling plans:

- Areas covered with lawn vs. dirt vs. rocks or wood chips.
- Soil sampling depths. According to the article, most of the lead and arsenic is limited to the first 12 to 18 inches of top soil, but the arsenic may migrate deeper. What if there is a hot spot for lead and/or arsenic between 3 and 4 inches?
- Anticipated use of areas vs. actual use of areas. Although areas may be planned and built for specific uses, they may actually be used differently than anticipated (e.g., used more or less than expected). Children are particularly good at using areas differently. For example, they may begin digging somewhere unusual or slide down hills on boxes, killing the grass and exposing soil. So some additional sampling may be performed later in high-use or high-risk areas.

Step 4: a. Assume you collected three soil samples and got back the results reported in the table below. Calculate the average concentration of lead and arsenic, assuming your samples were pooled into one composite. Fill in the table with your averages.

Sample Number	Location	Arsenic Concentration (in ppm)	Lead Concentration (in ppm)
1	Side yard	20	1,000
2	Front yard	2	75
3	Back yard	5	60
Composite Average		9	378

b. Explain how making composite (or combined) samples from different areas (e.g. side yard, front yard, and back yard) runs the risk of missing significant hot spots. Discuss this with respect to the following:

- Action levels of 10 ppm for arsenic and 400 ppm for lead.
- The possible use of the areas, especially by children.
- The need for cleanup. What if the composite averages were 40 and 400 ppm?

Student response will vary, but make sure all three bullet points are addressed in a logical and clear fashion. A sample response is: The average shows levels of arsenic and lead below the action levels of 10 ppm for arsenic and 400 ppm for lead, which may incorrectly lead someone to believe the entire yard is safe; thus, no cleanup would occur. However, the side yard is above the action levels. If there were a slide (which has dirt in the landing area) or a digging spot for the dog and the kids in the side yard, this could pose a health risk, especially for young children. These data could also impact cleanup. If the averages reached the cleanup levels, people may try to remove all of the soil in the side, front, and back yards, which would be very expensive. The soil that really needs to be removed is in the side yard.

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Give us your feedback! Send comments about this lesson to ehpscienceed@niehs.nih.gov.

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Student Instructions: Arsenic and Lead Scavenger Hunt

Step 1: Read the article "The Apple Bites Back: Claiming Old Orchards for Residential Development" and answer the following questions:

a. What are the sources of lead and arsenic found in soil?

b. What are the health effects of exposure to lead and arsenic in soil?

Step 2: Residents of a local community have become concerned about the possible presence of lead and arsenic in their soil from pesticide contamination. They would like to collect samples of soil and have it analyzed, but are not sure what to do. They have asked the local science teachers and their classes to develop a sampling plan. One residential property and one community park have been chosen initially by the community to be sampled.

You have researched the science behind developing a sampling plan and have learned the following:

- Sampling plans should take into account uniquely vulnerable individuals who are more at risk of being harmed by the contaminants. Typically, these individuals are children (especially very young children), the elderly, and individuals who are already sick from other health problems.
- Sampling plans should take into account the pathways of exposure and how the land is being used. Pathway of exposure refers to the way the contaminant gets from its source to humans. Humans must be exposed or come in contact with a contaminant in order for the contaminant to cause any health problems. For example, uncovered soil contaminated with lead and arsenic could be blown by the wind into the air where any person in the area could inhale the dust. Soil contaminated with lead and arsenic could also come in direct contact with a child playing in the dirt, and then the child may ingest some of the dirt by hand-to-mouth contact. If the soil is covered by a building or pavement, there is little risk the soil will come in contact with humans, and there is less concern.
- Soil concentrations of contaminants are highly variable from one spot to the next and can form "hot spots," or isolated locations where the contaminant concentration is very high. These "hot spots" are difficult to detect.
- Sampling plans should collect sufficient number of samples at the right locations in order to be able to answer the question of whether the concentrations of the contaminants in the soil exceed safe levels. The more samples you collect and analyze, the better you are able to answer this question. The number of samples collected, however, is usually limited by the cost. Each sample collected can cost $50 to analyze for lead and arsenic. Therefore, sampling plans are expected to collect the smallest number of samples needed to answer the question.

Step 3: Develop a sampling plan for the area plan (residential property or community park) assigned to your group. Mark on the plan the exact locations where you would collect samples. Remember, you must be able to explain to the community the rationale and cost for your plan. Assume each sample you collect costs $50 to analyze. Answer the following questions:

a. Which area did your group use to develop the sampling plan?

b. Mark on the plan where you will sample. How many samples did you collect?

c. What was the total cost of implementing your sampling plan?

d. Explain the strategy you used to decide where to collect the samples.

Step 4: a. Assume you collected three soil samples and got back the results reported in the table below. Calculate the average concentration of lead and arsenic, assuming your samples were pooled into one composite. Fill in the table with your averages.

Sample Number	**Location**	**Arsenic Concentration** (in ppm)	**Lead Concentration** (in ppm)
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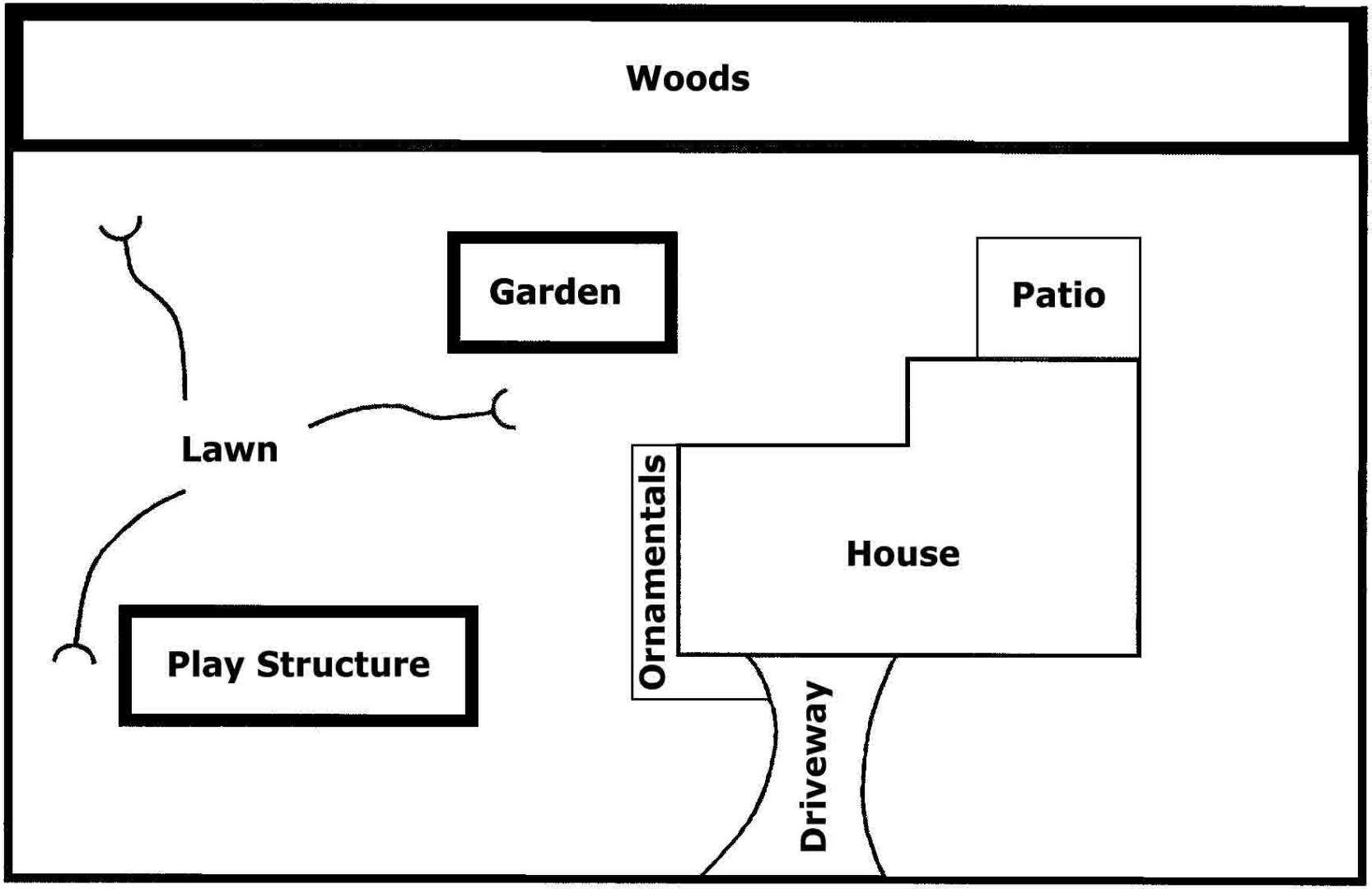
Composite Average			

b. Explain how making composite (or combined) samples from different areas (e.g. side yard, front yard, and back yard) runs the risk of missing significant hot spots. Discuss this with respect to the following:

- Action levels of 10 ppm for arsenic and 400 ppm for lead.
- The possible use of the areas, especially by children.
- The need for cleanup. What if the composite averages were 40 and 400 ppm?

Residential Property Worksheet



Community Park Worksheet