Chapter 5

A Field Study of Interspecific Relationships

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Introduction

Modern ecological field studies are largely quantitative while purely descriptive work is often relegated to the status of “natural history.” We feel, however, there is a place for descriptive outdoor studies in a biological program if they are carried out in a vigorous and challenging way. The present exercise has been carried out successfully for a number of years in one of the 3-hour, weekly laboratory periods in an introductory university biology course. However, by considering fewer relationships, it could be adapted to fit shorter laboratory periods. By varying the depth and details covered in each relationship, it could be modified for use by a high school class or a more advanced ecology class. It is useful as a supplement to, or substitute for, theoretical classroom work (lectures, discussion, audio/visuals) but is not meant to be an alternative to quantitative ecological studies which are essential to any field program. Introductory students often benefit most in their quantitative studies if they have first had a chance to survey a community and to observe and think about the types of organisms present and their biological interactions. Ample opportunity for follow-up quantitative work will arise from this exercise.

We use this exercise as part of a study of population ecology, but it also relates directly to the study of food webs and trophic levels. Textbooks often contain examples of interactions which are exotic or at least out of the realm of the students' daily experiences. Our purpose is to develop the students' awareness of the interrelatedness of the organisms in a community by studying local examples of interspecific relationships; for example, those that occur immediately at their doorstep in whatever surroundings they happen to live. This exercise is readily adaptable to any locality, whether it be urban or rural. Detailed observation is stressed and students are encouraged to hypothesize about the nature of the relationships and the degree to which the organisms may regulate one another's populations. The production of good field notes and sketches is required.

In order to keep an exercise of this type from becoming just a casual “look/see” outing, instructors must be well versed in the life histories of the organisms involved in at least five or six common local relationships and be aware of at least a dozen or more others. This requires detailed field preparation as well as literature consultation. Each year new relationships are observed. The details of these can be researched between semesters and, along with relevant literature, can be added to the instructor's repertoire. As well, students must be encouraged and challenged to observe, speculate, think, and discuss matters at hand.

The Introduction section of the Student Outline that follows summarizes some of the topics previously discussed in class and the Learning Objectives and Procedure sections alert the student to the purpose and methods of the study.

Student Outline

Learning Objectives

At the end of this outdoor exercise, you should:

1. Submit for grading the completed record sheets of a general description of the study area and weather conditions (Sheet A), all interactions encountered in the field (Sheets B and C), and the completed map of the sample points and the route taken.
2. Be able to discuss in detail several types of local interspecific interactions, showing how the organisms interact to regulate population size.
3. Be able to give local examples of at least five of the interaction types listed in Table 5.1, with at least one example from each of the five kingdoms of living organisms.
4. Be able to speculate on the possible origin of at least one interaction encountered.
5. Using one example, be able to discuss the uncertainty involved in attempting to classify some interactions.

Introduction

Communities consist of all of the organisms in a particular area. Every organism occupies its own niche and has its own requirements for survival, many of which include interactions with other species in the community. Each species encounters many others and a variety of interactions can occur in a complex network that forms the basis of community stability. All of these interactions are sometimes broadly called “symbiotic” or “living together” relationships, although the term symbiosis is often used in a more restricted sense to refer only to those relationships in which the organisms remain in constant contact.

When species interact they often help to regulate one another's population size. There are three basic effects; the relationship will cause the population of one, or the other, or both, to increase (+), to decrease (-), or it will not seem to affect population size at all (0). Using combinations of these possibilities, Odum (1983) has classified these interactions as listed in Table 5.1.

As with all human attempts at classifying the living world, this scheme is not absolute, but provides reference points along a continuous gradation from neutralism to mutualism. Often, specific relationships fall somewhere between two types and a judgement will have to be made on the basis of our knowledge about the relationship.

Direct interactions, such as one organism feeding on another, can often be determined and classified quite readily. Others like mycorrhizal associations of plant roots and fungi may require much field and laboratory study to be understood fully. The web of life in a community also produces many indirect interactions where population regulation may occur in complex and subtle ways. For example, a Snowshoe Hare and an earthworm do not interact directly; therefore their association in the community might be considered to be neutralism. However, indirectly the two enhance each others' growth rates. The hare's droppings add to the organic litter used by the earthworm, and the earthworm's soil enrichment and aeration activities increase the food supply of the hare. In addition, relationships may change over time and short-term and long-term effects can be quite different. A predator might serve to decrease a population of prey and keep it from outstripping its food supply, therefore preventing a drastic population crash. In this case the short-term interaction appears to be negative for the prey, but in the long term it can benefit the prey by stabilizing its population. The difficulty of understanding the many direct and indirect interactions amongst the organisms of a community and the intricate relationships that show up when one looks closely make this an exciting and challenging field of study.

In practical terms, greater ecological knowledge of this type is essential to allow the ever-increasing human population to make wise choices in environmental manipulation. For many years humans have been manipulating interspecific interactions, sometimes purposefully and sometimes unwittingly, resulting in pest problems and occasionally in successful control measures. Biological control usually involves the introduction of a new species that will prey on or parasitize undesirable species. Over 45 such introductions have been made to the island of Newfoundland alone, some of which, such as the introduction of Masked Shrews to control the Larch Sawfly, have been quite successful. However, the literature is also rife with examples from around the globe of introductions that have resulted in crop damage, disease, etc., as a result of newly-introduced species flourishing in the absence of their natural controls.

Table 5.1. Types of interactions between populations of two species.
Adapted from Odum, E. P., Basic Ecology, Saunders, Philadelphia, 1983.

Interaction	Species 1	Species 2
1. Neutralism	0	0
2. Direct (interference)	–	–
competition	–	–
3. Resource competition	–	0
4. Amensalism	+	–
5. Parasitism	+	–
6. Predation/herbivory	+	0
7. Commensalism	+	+
8. Protocooperation	+	+
9. Mutualism	+	+

Equipment and Materials

Per individual:
Hand lens
Pencils (2H)
Extra slip-on pencil erasers
Pencil sharpener
Clipboard folder
Record sheets
Metric ruler, 15 cm in length
Camera (optional)
Binoculars (optional)

Per group:
Shovel
Hatchet
Sturdy knife
Metric tape measure

Procedure

During this field trip, an attempt will be made to locate as many of the nine types of interactions listed in Table 5.1 as possible. In addition, examples will be sought from each of the five kingdoms of living organisms: Monera, Protista, Plantae, Animalia, and Fungi. Close observation, discussion, speculation, and the preparation of good field records should foster a greater understanding of the interdependence of the organisms in a community and will provide a framework for future study.

You should complete Field Record Sheet A (Table 5.2) before the outing. The time of year and the weather conditions prior to the field trip will affect the types of interactions encountered and the life cycle stages in which organisms can be observed. On the field trip, leaders will take the group on a pre-arranged route through various communities and habitats. The instructors will point out specific examples of interactions encountered and will lead in group observation and discussion. A Field Record Sheet B (Table 5.3) should be completed for each of these interactions studied in detail. Both students and instructors are encouraged to locate additional examples along the route; these can be recorded briefly on the Field Record Sheet C (Table 5.4). The location of each interaction and the route taken should be plotted on the map that is provided (Figure 5.1). Field records will be collected upon return to the laboratory and will be graded on the basis of accuracy, detail, and completeness.

Notes for the Instructor

In order to carry out an exercise of this type properly the instructors must be thoroughly familiar with the area to be used and be aware of several interactions that can be readily observed. In the 3 hours allotted, we have found it best to go into only four to six relationships in detail for recording on Field Record Sheet B. For these interactions the instructor must have carried out a literature review and be completely familiar with the life histories and ecological and economic importance of the organisms involved. Other interactions (a dozen or more) to be recorded on Field Record C will require less detailed knowledge, in some cases only identification of the organism involved and some basis for speculation as to the possible interaction.

We have found it best to begin with one of the detailed interactions (Field Record Sheet B) and then to continue as a group along a pre-arranged route to the second detailed interaction. Between these detailed interactions, several more cursory stops should be planned for recording on Field Record Sheet C. Careful observation will always bring to light new associations. Students should be encouraged to make “discoveries“ on their own. It is not necessary to cover any preset number of relationships in order to fulfil the objectives, but rather it is the quality of the observations, speculations, and discussions that determines the success of this exercise. Usually a thorough reconnaissance of any community will produce many more interactions than can be studied in a 3-hour period.

Tables 5.2, 5.3, and 5.4 show samples of completed field records indicating the approximate detail expected of students. At each of the interactions we attempt to follow a general sequence of discussion:

1. Point out evidence of an interaction and allow all students to observe the structures involved. Some students will be more concerned with record keeping than actual observation and thought about the organisms. It is important that all students make careful observations initially before any details of the interaction are given.

2. Inquire of the students about the identity of the organisms involved. If none of the students can supply the names, then these should be given by the instructor at this time. You may wish to use scientific names as well as common names depending on the level of the students. It is not

necessary to burden students with excessive scientific nomenclature which may distract from the spontaneity and excitement which can be generated in such an exercise.

3. Present an explanation of the life histories of the organisms involved without directly indicating the type of interactions.

4. Inquire of students as to the type of interaction (Table 5.1). Begin by determining the (+), (-), or (0) effect on each organism in the interaction. Discuss alternate possibilities; for example, Is the algal/fungus symbiosis in lichens really mutualism or perhaps commensalism or parasitism? The instructor may offer some evidence that could sway the decision one way or another, but reasoning should be encouraged.

5. Inquire of students how this interaction may have originated and discuss.

6. Allow time for notes and sketches. It is critical that neither too little nor too much time is allowed for recording. One will lead to poor records and the other to distraction from the purpose of the study.

Table 5.2. Field Record Sheet A.

Student *Mary Smith* Date *March 26, 1984*

General Description of Study Area: *The study area is located on the Sir Wilfred Grenfell College grounds, Corner Brook. There are three major communities: ① disturbed areas - cleared rubble and weedy areas around parking lots, road-sides, and power lines; ② forest - spruce/fir forest with scattered birch and maple; ③ fen - open sedge/ericaceous peatland.*

Weather Conditions -

a) for the two weeks prior to the field study:

March 12-16: Warm, sunny, spring-like. High 12°C. Low 0°C
March 17-23: Freezing rain and snow flurries. 10 cm of snow on the 21st. High 0°C. Low -10°C
March 24-25: Cloudy and cold. Strong NW winds. High 1°C. Low -6°C

b) on the day of the field study:

Overcast with light winds. Snow flurries in the morning. Temperature 1°C. Snow cover between 2 and 3 metres in open and wooded areas.

Table 5.3. Field Record Sheet B.

Student Mary Smith Date March 26, 1984

Route Reference Point on Map 9

Habitat: Open area in immature spruce / fir forest. The gall was found on a blueberry shrub, growing at the base of a white birch.

Organisms Involved in Interaction:

Blueberry shrub (Vaccinium angustifolium Ait.)

Blueberry gall wasp (Hemadas nubilipennis Ashm.)

Type of Interaction (category and details): With her ovipositor, an adult wasp inserts eggs into the bark of a young blueberry shoot. Eggs are deposited in a row along one side of the shoot. The developing eggs stimulate the plant to produce a gall in which the wasp larvae develop and feed. The gall often becomes kidney-shaped because most growth occurs on the side in which the eggs were laid. The larvae overwinter in the gall. In spring, when the blueberry plants are putting forth new growth, adult flies emerge through small holes and the life cycle is repeated.

The interaction is parasitism: blueberry shrub − ; blueberry gall wasp +. The wasp gains nutrients and protection. The shrub loses energy and flowering and fruit production are reduced.

Sketches:

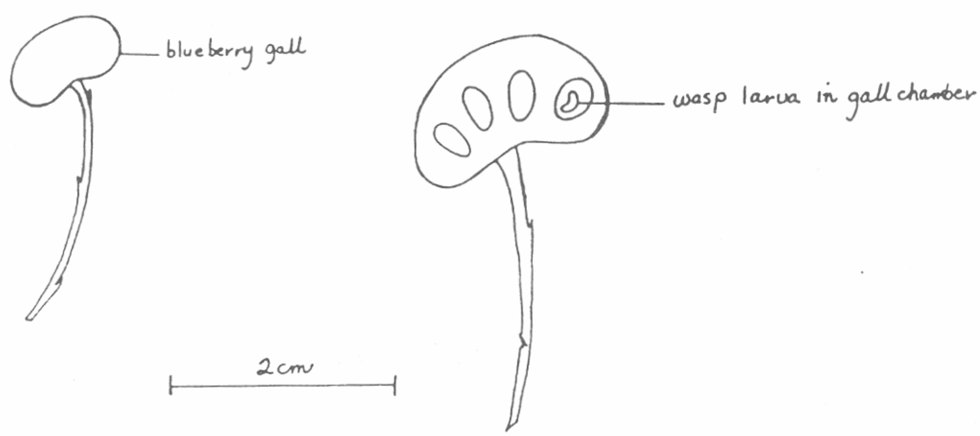

Table 5.4. Field Record Sheet C.

Student Mary Smith Date March 26, 1984

Map #	Organisms	Habitat	Type of Interaction	Notes
5	Old Man's Beard Lichen (*Usnea* sp.) Black Spruce Tree (*Picea mariana*)	Mixed spruce-fir forest	Commensalism +/0	The lichen gains a substrate on the tree limb, exposed to light for photosynthesis. The tree is neither harmed nor benefitted by the lichen

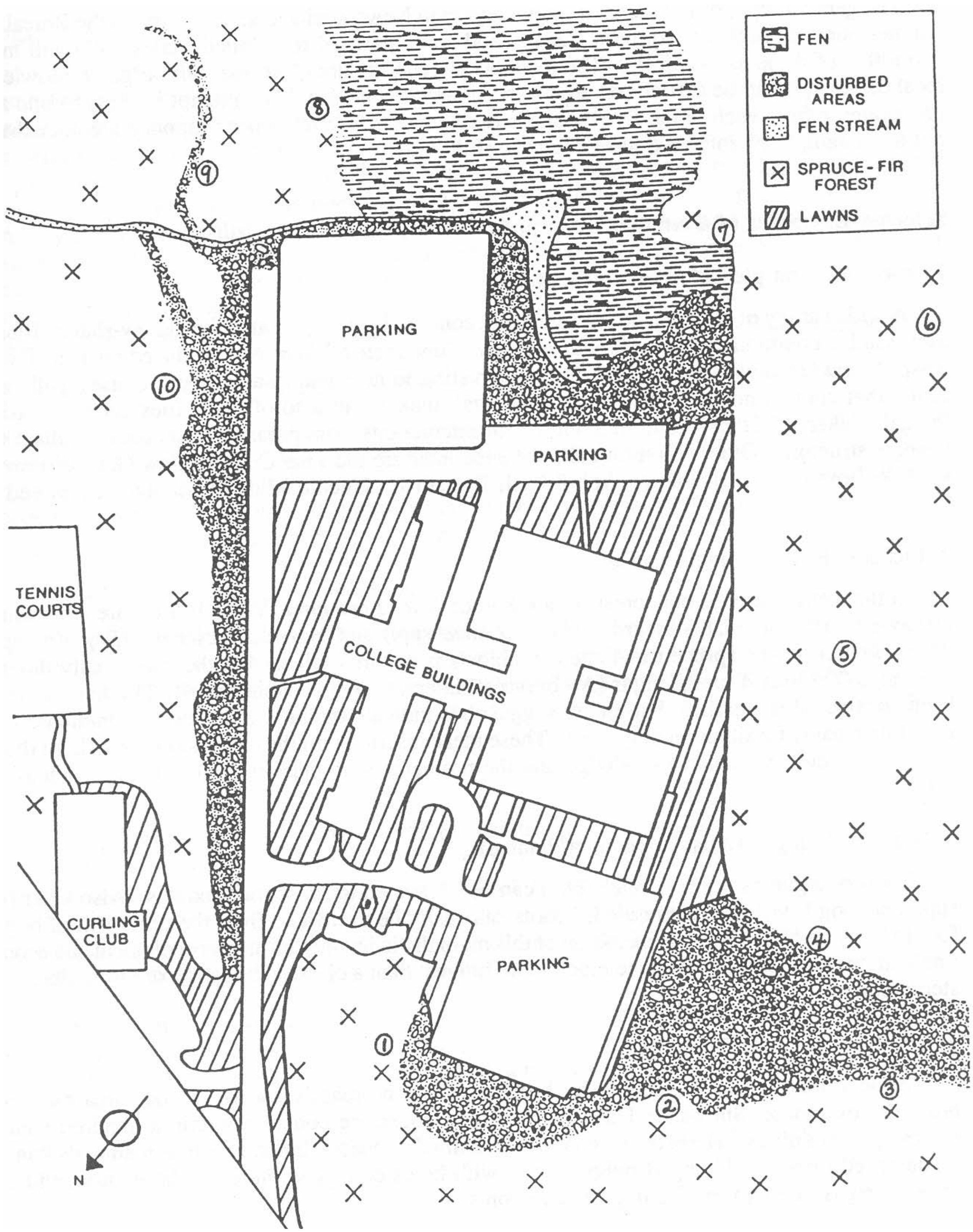

Figure 5.1. Map of study area showing field trip route and sample points.

The general types of interactions we encounter in Newfoundland are common to the Boreal Forest Biome found throughout Northern Canada and some parts of the United States. We will mention just a few of these as examples. The exercise is general enough so that with a good knowledge of local ecology, it can be carried out anywhere, in any community. An attempt is made to find at least one example from each of the five recognized kingdoms. The references supplied are not exhaustive but are a sample of some we have found useful.

Selected Examples of Common Interspecific Interactions

1. Insect galls on plants (Animalia/Plantae)

A wide variety of galls can be found in most communities. In our area the kidney-shaped Blueberry Stem Gall is common and conspicuous on *Vaccinium angustifolium* Ait. produced by a small chalcid wasp, *Hemadas nubilipennis* Ashm. It is interesting to note that in a number of cases, galls will be found that contain not only the larvae of the gall maker, but also of guest flies and/or parasites of the gall maker. This can result in a number of interactions from parasitism to commensalism within a single structure. Other common galls we encounter are the Pine Cone Willow Gall, Willow Stem Gall, Willow Leaf Gall, Spruce Aphid Gall, Balsam Fir Needle Midge Gall, and Knapweed Head Gall.

2. Lichens (Protista/Fungi/Plantae)

In the wetter parts of our forest, Black Spruce (*Picea mariana* (Mill.) B.S.P.) are conspicuously festooned with Old Man's Beard Lichens (*Usnea spp*.) and Horsehair Lichens (*Bryoria spp*. and *Alectoria* spp.). The spruce tree/lichen symbiosis is commensalism, but the one usually thought of is the alga (*Trebouxia spp*.)/fungus (Ascomycete) interaction of the lichen itself. This has traditionally been considered mutualism, but recent suggestions indicate the possibility that a commensalistic or probably a parasitic situation may exist. These ideas inserted into the discussion can help to illustrate the inadequacies of human knowledge and the problems with classification schemes such as Table 5.1.

3. Nitrogen-fixing organisms (Monera/Plantae)

Roots of legumes (clover, vetch, etc.) can be excavated to show root nodules. Also alder (*Alnus* spp.) and Bog Myrtle (*Myrica gale L*.) roots can easily be excavated from the peaty soil of bogs and fens to show nodules. A field discussion of this mutualistic interaction and its ecological and economic implications can certainly produce much more interest than a classroom lecture or discussion in more sterile surroundings.

4. Herbivory (Plantae/Animalia)

In most areas, signs of feeding by herbivores can be readily found. In our area evidence of browsing by moose, Snowshoe Hare, and Ruffed Grouse are common within a hundred meters of the campus buildings. Herbivory by domestic animals, insects, birds, or small mammals can often be observed directly. Cropped twigs, leaves with holes or ragged margins, defoliation, and a host of other signs attest to the feeding of herbivores.

5. Fungal/plant/animal interactions (Fungi/Plantae/Animalia)

Everywhere plants can be located exhibiting signs of fungal infection. Parasitic rusts and smuts are common and these have complex and interesting life cycles. A common parasitic fungus of our area is the Black Knot Fungus (*Dibotryon morbosum* (Sch.) T. & S.) producing black crusty lumps on the twigs of Pin Cherry (*Prunus pennsylvanica* L.) and on domestic plums and cherries. On the black knot produced by D. morbosum can be found a variety of other microscopic fungi resulting in a mini-community of numerous interactions which illustrate well the complexity of the web of life. A very common mutualistic plant/fungus interaction is the mycorrhizal association. It has recently become apparent that many, if not most plants, exhibit some sort of a mycorrhizal symbiosis. In our area, examples of the characteristic thickened and branched fungal-encased root ends of trees and shrubs can be excavated from the peaty areas of bogs and fens. Examples of fungal/animal interactions may or may not be available on the day of the outing (e.g., athlete's foot, ringworm, etc.).

6. Pitcher plant associations (Plantae/Animalia)

Not only do pitcher plants act as predators on a variety of invertebrates they trap, but a number of invertebrates may also spend all or part of their life cycles in the pitcher plant without being killed or digested. Such inquilines include mosquito larvae, flesh fly larvae, rotifers, nematodes, mites, and copepods living in a commensalistic or perhaps neutralistic relationship (perhaps others?). The pitcher plant is itself a complex community that can be investigated at great length.

7. Dwarf Mistletoe/Black Spruce interaction (Plantae/Plantae)

The Dwarf Mistletoe (*Arceuthobium pusillum* Peck) is a flowering shrub that parasitizes Black Spruce and causes the formation of "witches' broom" growths. This interaction is of considerable interest because it is one of the few examples of an angiosperm parasite in our area. It is also intriguing because of the unusual way the mistletoe seeds are dispersed and because of its economic importance in forestry.

8. Other examples

Even a squirrel in a tree, or a crow flying by, can trigger a discussion. Is the squirrel carrying out predation/herbivory when it feeds on conifer seeds or is the interaction more of a mutualistic one, with the squirrels' distribution of some seeds resulting in greater regeneration and dispersal of the conifer species? Which of the roles of crows is most significant: mutualism when they behave as scavengers, predation when they eat other birds' eggs, protocooperation when they alert other creatures of danger, or competition when they eat the crops of humans?

Although the above examples are from a wooded, somewhat rural environment, some of these as well as many other common organisms such as pigeons, seagulls, rats, lichens, mushrooms, and insects can readily be observed in urban or pastoral settings. The following are a few of the many other interactions we have encountered:

(a) The stem-boring Willow Weevil (*Cryptorhynchus lapathi L.*) is fairly common in our area. A number of other wood-boring beetles or their tunnels or larvae can be found in Balsam Fir, spruce, etc.

(b) The Four-eyed Spruce Bark Beetle (*Polygraphus rufipennis* Kirby) and other bark beetles produce galleries and tunnels in the bark of conifers.

(c) Witches' Broom Fungus (*Pucciniastrum goeppertianum* (Kuhn) Kleb.) produces brown shiny abnormal growths on *Vaccinium* spp. such as the Common Blueberry (*Vaccinium angustifolium* Ait.).

(d) Wood-decay fungi may cause heartwood rot in living trees. Evidence of the fungus is the soft heartwood containing the white mycelial fragments of the fungus when the tree is opened with an axe. Often trees in advanced stages of heartwood decay are broken off by high winds.

(e) A variety of pollinator insects can usually be observed visiting flowers on any summer day.

(f) Herbicide damage following spraying is common along roadsides, railroads, powerlines, and on lawns.

(g) A variety of common forest insects or evidence of their feeding can usually be located; for example, the Spruce Budworm (*Choristoneura fumiferana Clemens*), etc.

(h) Many seeds and fruits have adaptations promoting their dispersal by other organisms; for example, color, structure, taste, nutritional value, etc.

Follow-Up Exercises

This exercise was designed to introduce the student to some ecological principles and local organisms without quantitative analyses. We find that students confronted with new principles, new organisms, and new quantitative methods, sometimes fail to comprehend the principles due to undue attention to the methodology. This exercise does, however, make a good foundation on which to base later, quantitative field exercises. The ecological laboratory manuals by Cox (1980), Darnell (1971), and Wratten and Fry (1980) include some good examples. The following are some exercises we have used:

(a) Plant-herbivore interactions: We have measured herbivory by, and food preferences of, moose, Snowshoe Hare, and insects using quantitative sampling and statistical analyses.

(b) Resistance to fungal infection by living and dead wood: We tested the effects of extracts from the wood on growth rates of several fungi in culture, following Darnell (1971).

(c) Quantitative estimates of fungal infections in deciduous and evergreen broadleafed shrubs: After measuring the areas of infections in samples of leaves, we tested the inhibitory effects of leaf extracts on fungal cultures.

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The following references are arranged to correspond to the previous section entitled "Selected Examples of Common Interspecific Interactions."

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