SOIL CONSERVATION: BIOLOGICAL INPUT TO THE SENATE HEARINGS

The following excerpt is taken from proceedings of the Senate Committee considering soil and water conservation in Canada, a group that had not previously been exposed to information on the biological features of soil. The importance of the soil fauna has been pointed out several times by entomologists: for example, the Survey's brief appeared in *Bull. ent. Soc. Can.* 14(1), Suppl., 5 pp., 1982, and relevant conference proceedings have just been published, as reported on page 1.

The following presentation was made by Dr. S.B. Hill of Macdonald College.

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The Acting Chairman: The meeting will come to order. I will ask Professor Hill to take the floor, and remind him that we are increasingly pressed for time. I would ask him to limit himself to about 15 minutes, as the list of speakers is quite long. You have the floor, Professor.

Professor Stuart Hill, Department of Entomology, Macdonald College, McGill University: Thank you Mr. Chairman. Honourable senators, ladies and gentlemen, I have read with interest the proceedings of this committee and I commend honourable senators for tackling this problem, which is one of the most important problems that face us today in Canada. You have heard that the situation has reached a critical level in most regions of Canada. While the presentations to date adequately describe the problem, few examine its fundamental causes and none deals with the nature of soil in any more than a superficial way. Rather than repeat what has already been said, I will use my time to introduce you to the life in the soil and to the holistic, ecological approach to its management.

I come to honourable senators from Macdonald College, more particularly, from the Entomology Department, of which I am a professor, and from Ecological Agriculture Projects, which was established in 1974 to provide a resource centre where people from around the world could find information on how to design sustainable, nourishing food systems; that is, systems, for example, in which soil fertility and productivity are maintained and enhanced rather than degraded. Ecological Agriculture Projects came into being as a result of the foresight and concern for problems such as soil degradation of Dr. and Mrs. David Stewart of the Macdonald-Stewart Foundation. As honourable senators may know, Dr. Stewart died last Friday, so I would like to dedicate my remarks today to his memory and to acknowledge that it is largely because of his support that I am here today, able to provide you with a rather different perspective than you have been exposed to up to now.

First of all, I would like to start by stating my initial assumption, and that is that the collective wisdom and intelligence in this room is capable of solving the problem of soil degradation. Otherwise, I would not be here. However, I would add that we need to take a very different view from that which we have taken up to this point.

What is often not realized is that soil is not a dead system but is very much a living system. In fact, when you look out on the landscape there is more life below the surface of the soil than above it. Most presentations to this committee have been delivered as though we were dealing with something dead. I want to emphasize that we are dealing with a living system.

I also want to point out that, when we look at subjects such as soil degradation, we often move through this series - and I think we have seen this to some extent this morning - whereby we start off with a problem that seems relatively straightforward, soil degradation, we think that there must be a solution, and then, as we listen to presentations such as your committee has heard, we start to find that it is complex - in fact, paralyzingly complex - and we feel very confused. The state we need to reach is the third stage, which is profound simplicity where the truths of the situation emerge. Rather than introduce this idea to you with more data initially, I would like to introduce it to you by quoting a poem, because poetry often conveys

meaning more clearly than data. It is a poem by Elizabeth Odell and it goes like this:

> Flat outstretched upon a mound of earth
> I lie; I press my ear against its surface and
> I hear, far off and deep,
> the measured sound of heart
> that beats within the grounds.
> And with it pounds in harmony
> the swift, familiar heart in me.
> They pulse as one, together swell,
> together fall. I cannot tell my sound
> from earth's, for I am part
> of rhythmic, universal heart.

These words convey, essentially, a philosophy relating to the soil. The problems we have with the soil exist because we have separated ourselves from the soil. The profound simplicity, in a sense, is that we have to close that separation, or, as Sitting Bull stated much more simply, "The earth and I are of one mind." That is the point we have to reach if we are to generate a way of managing soil that is not going to lead to degradation.

To look at it another way, we have to study the problem much as your committee is doing. More than that, however, we have to spend time with the environment we are talking about. It is very difficult to understand these problems and to understand how the soil functions when we are sitting in a city in an air-conditioned room.

Thirdly, we need to imitate the way the system works and to work with the natural processes. To understand that simple system, we need to see that agriculture is a production-consumption-recycle process. All of our emphasis in agriculture has been on production and we have taken attention away from recycling. The soil, however, is the recycle part of that system, and, if we want it to function, we must pay attention to providing it with the things it needs to keep working.

As I said earlier, removing the separation between us and the soil is really a matter of integrating our life-style with the way the soil works. In that way, we create a balance between us and the soil, paying attention to the feedback when the soil is being washed away and recognizing what that means and what we must do about it.

I would now like to move from studying the soil to spending time with it, in a sense, to take you down into the world of the soil. People often think that soil is just a pile of dirt, but it is more likened to something like the hotel where we are right now. Soil has different things going on in different levels. It is a stratified material. When we come along and jumble it up, we initially create problems. We therefore have to recognize the layered nature of the soil, the litter, the humus and the mineral layers, for example. If you look at it in terms of space, about half of the soil is solid material, while the other half is space. Half of that space is filled with water. The life in the soil is divided up into a number of organisms that are swimming around. They are basically aquatic and swim in the water around the particles of soil. It is these organisms that are in the soil which maintain the soil's fertility. It is not so much the farmer putting on fertilizer, which is an indirect way of dealing with fertility. If we want to maintain the fertility of the soil, it is those organisms that we have got to cater to. There is a whole range of such organisms. In an average acre or so of fertile soil, there can be as many as a thousand different species. We can turn that organic matter into the surface of the soil with equipment. When we do that we are providing these organisms with food. We can also grow green manure crops and turn those into soil. In this way we provide food for the organisms in the soil. When this material is provided to the organisms they start to break it down and it begins to look like this. It is the by-product of this breakdown which maintains the structure and health of the soil. When a dead animal falls to the ground maggots and beetles soon arrive on the scene and break it down. Not long after that process starts we are left with some bones; the flesh of the animal is gone. If it were not for these organisms in the soil we would be up to our necks in waste.

So the production of healthy soil is a decomposition process - it is the breaking down of dead organic matter into humus and the breakdown of the parent rock to minerals. The combination of these two results in mineral-organo complexes. It is from these complexes in the humus that nutrients are taken up to plants and the system is maintained. If we want to have healthy soil we must do what we can to promote this decomposition process, since that is how soil is formed. What I am saying is that if we cater to the needs of the organisms in the soil they will maintain the soil and the soil will maintain us. This is why it is very important to be familiar with the organisms I am showing you now.

This slide depicts some of the organisms in the soil. I believe I have passed around a sheet which is the same as this picture. There are bacteria, moulds or fungi, and protozoa, which are one-celled animals swimming around in the water film feeding on the bacteria. This next slide shows more protozoa and some other exotic animals which swim around in the water film.

This next slide depicts nematodes, most of which are beneficial and not harmful at all. There is a

tendency to think that all worms are harmful. Some of these organisms have very intricate relationships with other animals in the soil. For example, these nematodes take rides on this mite, which is how they get around in the soil. This is a picture of some mites, which are most beneficial. In fact, less than 1 per cent of arthropods, which includes insects and mites, do any harm. Again, there is a tendency to believe that insects and mites are harmful.

This slide depicts some of these other organisms. In order to illustrate the intricacy involved, this next slide shows a little white dot on the left, which is a mite taking a ride on another mite.

The next slide depicts mites taking a ride on a dung beetle. You can imagine the scene. If these mites happen to be the type of mites associated with animal dung, their legs are very short and they would have quite a long walk to get from one cow cake to the next. So they have tuned into the dung beetles which have wings. When the dung beetle is about to take off it gives off an odour which says, in effect, "the bus is leaving". The mites jump on the back of the beetle and are transported to the next pile of dung. These are just some of the wonders which are taking place down there. When we think in our arrogance that we are running the system it is important to remember this type of relationship.

There are other mites which are attracted by flies and use these flies to transport themselves from one location to another. There are small insects with feather-like wings, as shown in this slide. Then we have ants, white worms, or pot worms as they are sometimes called. In fact, much of the fertility in soil is really a result of the waste materials of these organisms, that is, the fecal packages which they deposit.

The next slide shows earthworms - the intestines of the soil, as Aristotle called them. In a square metre of fertile soil there may be over 300 earthworms. If there are no earthworms the soil is in poor condition. There are other types of nematodes which-are not beneficial. Actually, some of them can cause problems. Fortunately, the soil has its own way of dealing with these types of organism.

The next slide depicts fungi which will actually trap nematodes by giving off an odour which causes the nematode to swim into the little nooses formed by the fungi. The noose tightens and the fungi digest the nematode. By providing the soil with organic matter we provide an environment where the fungus can grow, which then catches the nematodes. We do not need to put out nematocides or different types of poisons on the soil to deal with these harmful organisms; rather, we need to maintain the fertility of the soil. As a doctor friend of mine once said, "We do not suffer from a headache because of a deficiency of aspirin in the blood." Likewise, we do not suffer from nematodes because of a deficiency of nematocides, but, rather, because the soil is not functioning. In a way, the nematode, which is a pest, is telling us that we are not running the soil properly. Rather than kill the nematode, we should take notice of the problem and deal with it at its causal level.

There are other pests such as grass grubs; but even these provide methods of control. Most of them are attacked and killed by at least half a dozen insects. By providing the environment with these organisms we can control the pests. There are a great many predators which feed on these organisms, such as centipedes and ground beetles, both depicted in this slide.

The general tendency we have is to get out onto the fields and spray. However, that spraying kills most of the beneficial organisms in the soil. It will also kill this person depicted in the slide, if he continues to spray without protective clothing. This photograph is from a pamphlet which sets out methods on how to spray, which completely disregards the need for protective clothing. The following slide depicts the Italian model; and this one an upside down model. At one time a great deal of spraying was done by airplanes, which causes incredible damage to the life in the soil. Widespread overuse of chemical fertilizers, particularly nitrogen fertilizers, has led to the acidification of soil, already heard in other presentations:

Basically, we are in the type of situation where we are destroying the soil and then enriching it with a few nutrients. A plant which grows takes a dozen or so nutrients out of the soil. We then put two or three nutrients back in and call it "enriched". We do exactly the same thing with food by processing the nutrients out, putting a few back in and calling it "enriched". We take the same sort of approach with respect to people through the use of toximolecular approaches.

The soil is really the foundation on which our society stands. If we do not learn how to manage the soil properly, we will not only be witnessing a degeneration of the soil but a degeneration of our society.

What we have to do is feed these organisms in the soil by returning the wastes to the soil, for example, as manure, and even through the composting of manure. People sometimes say that composting is a backyard activity. I show you the following slide which depicts a man putting compost on a quarter of a million acres of land In the United States. He calls himself a used hay salesman.

Composting is a good way to deal with wastes which otherwise would not be used. The following slide depicts woodchips combined with chicken manure which, six weeks later, results in nice rich black humus as a result of decomposition in a managed way. Composting is a way to build up humus and return valuable organic matter to the soil.

The following slide depicts a composting system which uses the waste heat from composting to heat a greenhouse in the winter. We can use green manure crops, crops that are grown specifically to build up the life in the soil and the fertility of the soil. This can also be accomplished through crop rotation, contour cultivation and the use of appropriate implements.

This slide is an example on a garden scale. Rather than turn the soil upside down, the person in the picture is loosening the soil. In this way the layered situation is maintained. Most of the life in the soil which I have been talking about lives in the top three centimetres of the soil. So if you turn the soil upside down and bury it it is just like taking the penthouse suite off this hotel and putting it underground - the occupants would not be too pleased.

So the kind of practices that I am recommending are using natural fertilizers where possible that do not acidify the soil, such as natural rock fertilizer where available, using non-intrusive and nondisruptive forms of irrigation, using minimal tillage practices when one converts the soil, for example, using chisel and disc cultivation rather than a moldboard plough to turn the soil upside-down. Other practices include inoculating the soil with beneficial organisms where possible, using trace mineral fertilizers, using crop rotation with legumes and soil improvement crops, mulches and the practice of keeping the soil covered, having much better soil and plant analysis services available to farmers and gardeners, and returning the organic material to the soil - animal manures, crop wastes, urban waste, compost, green manures and other plant materials.

I should now like to address the causes of the problem. The problem really comes down to the fact that if we look at the goals of modern agriculture it consists of productivity, profit and power. The problem with having these as goals is that there are no limits built into productivity and profit.

The natural system, on the other hand, operates within limits, and when one tries to use a system that operates without limits, it will behave as if there were no limits and you will gradually wear the system out. It is like whipping a race horse until it dies on its way around the race track, and that is basically what we are doing to the soil. We need goals that have limits built into them, such as nourishment, fulfillment, sustainability, flexibility, and the evolution of the systems being used. We have to have those sort of goals; we have to pay attention to the balance, to co-operate and to decentralize approaches because the solutions for one location are unique to that location. One cannot centralize solutions uniformly, like using fertilizers on infertile soil,-or pesticides on pests. The solutions are unique to each location and we must look at those distant causes of the problems that we face. The tendency in our society in searching for solutions is to search for solutions that are quick, powerful, direct, authored, and ignore the solutions that are long term, indirect, low powered and anonymous. Those are the solutions that will eventually lead to sustainability and improved management of the soil.

In looking at this situation in a broader way, there is often a tendency to look at solutions within a discipline or within a segment of society. I jut want to point out that finding solutions to these problems requires us to look at the whole. It is, in effect, like putting on a play that takes into account everybody in society. We have to have a script for researchers at all levels of government, for all communicators, educators, the general public, industry, commerce, farmers, and so forth. We cannot solve this problem by doing a piece of research. In fact, most research that is done simply monitors our extinction; it measures the problem; we have not had the guts to take action, so we have studied the problem. I think it is time that we had the guts and took action.

I have a few overheads that will illustrate what kind of action I think we need to take. With this problem there is a tendency to deal with it at the tips of the branches. What we have to do is get down to the roots if we really want to solve it. To illustrate that in another way, we often think the problem is of a certain nature, but sometimes the problem is a little different. A picture is worth a thousand words.

There are three approaches we can take in solving this problem. First of all, we can provide recommendations on ways to support people going in the right direction - that is, providing better education regarding those things I talked about in my presentation. We need better services for farmers who are interested in this, better research support and better legislation.

In the short term, it is necessary to provide rewards for people who are taking those initiatives. For example, if a farmer takes a field out of profitable production and uses that field for a soil improvement crop, that farmer suffers an economic loss. So, there must be rewards for individuals willing to do that. Those have to be looked on as short-term activities,

because we cannot have a sustainable society that only does sensible things because they are being rewarded.

Thirdly, we need some penalties for those disregarding rational behaviour and damaging the soil to the detriment of future generations.

My final list of factors involves things that my students should be aware of. This is a list of the questions that somebody thinking about these problems in soil should be able to answer. In a sense, it is a recommendation I make to myself as an educator at a university. Most students studying soil in universities could not answer these questions or are not familiar with them. That is partly why we have this problem. We have inadequate ways to measure the health of the soil. We tend to take a uniform approach to the management of soil, yet we need to be able to design unique approaches for unique situations. We need to be familiar with how the soil works and with the organisms I introduced to you and with the way the various management practices we use affect those organisms, which particular practices are appropriate for particular situations, and which cropping practices are ideal.

We need to be more familiar with soil improvement crops and with the value of weeds, which are often regarded as pests although often they are the very organisms that improve the soil and indicate how it is being mismanaged. We need to be more familiar with the relationship between soil implements and soil conditions, and more able to handle wastes and use them to improve the soil.

Finally, we need to calculate permissible levels of crop residue renewal, because we increasingly want to use material as energy sources. If we overdo that, we will destroy the soil. We need to make better use of rock fertilizers, ways to use plant hormones and natural substances to see the relationship between soil condition, food quality and human and livestock health. We need to relate management practices to climate and we need look at long-term effects of poisons applied to the system and find alternative ways to deal with pest problems. We need to know how buildings, fences, roads and machinery affect the soil. We need to develop what I call a polyculture system, that is, a more complex agricultural system, as opposed to a monoculture system. We need to help farmers set up their own experiments. We need to know how to explain to farmers, school children, consumers and people such as yourselves how the system works, and how we can work with it. We need to help people understand how rules and regulations affect the degradation of soil. In many cases the legislation generated by one department of government is protecting the soil, while legislation produced by another department is degrading it. We need to tell the farmers where they can go for support and help.

Thank you for your attention. I will be pleased to answer any questions you may have.

Senator Sparrow: Thank you for a most informative report on soil problems and soil degradation. That is the first comprehensive look we have had at life in the soil itself, and that is a very important aspect of our study.

What do you feel is the most important aspect of soil degradation? Is it soil erosion by water, wind, salination or acidification, or are you talking about the soil quality itself? Is that where the greatest deterioration is?

Professor Hill: I look at it sometimes from the point of view of a soil animal. As a soil animal I would say my living space has been degraded, my food source has disappeared, the organic matter I feed on has disappeared. Because of the loss of the organic matter, the soil is collapsing. So, the space is getting smaller and the poisons are getting more numerous and the protection at the surface is getting less because the soil is being left open. I think most of that relates to the loss of organic matter. So, if we can have soil management systems that return organic matter to the soil and keep it protected, as a by-product of that we will reduce erosion, we will build up the fertility of soil, we will minimize contamination of water. So, that illustrates this indirect approach that I am putting forward.

Senator Sparrow: What is the greatest threat to the life of the soil, is it compaction or just the loss of the organic material?

Professor Hill: I think the loss of the organic material and the exposure of the soil.

Senator Sparrow: Do you recommend that we should deal with the food for the soil and that then the rest of the aspects will look after themselves?

Professor Hill: Absolutely.

Senator Sparrow: What do you recommend for green manure?

Professor Hill: The specific green manure will vary from one location to another. For green manure we really need a mixture of crops such as legumes that produce nitrogen and add nitrogen to the soil, and crops that are very good at fixing carbon and that build up humus in the soil. We need a combination of things like grain, together with crops like buckwheat, on the one hand, and then things like clover, alfalfa and vetch, as well as beans. Those can be grown integrated into

the cropping system, for example, by using winter green manures as winter wheat, and that sort of thing. They can also be integrated by using them in between the rows of row crops - growing a legume in between rows of corn, for example. So, they don't need to take land out of production.

Senator Sparrow: What better legislation are you proposing?

Professor Hill: I think there needs to be protection of the high quality land we have from other uses. We just have to keep our agricultural land in agriculture. We have to be much more serious about that. We need some incentives for farmers, as I indicated earlier, who are taking these problems seriously. For example, in a study of organic farmers in the United States, it was found that the organic farmers were operating their farms on two-fifths of the amount of energy used on conventional farms. That system of farming was, in most cases, a system that returned organic waste to the a oil and built up the soil. If you were to look at the profits, you would see that they were about the same. They produced the same amount of crop on two-fifths of the amount of energy. As I said, those who are willing to take the chances and gain wisdom should be rewarded and supported.

Senator Sparrow: Thank you.

The Acting Chairman: Senator Lapointe?

Senator Lapointe: I have a short question, Mr. Chairman. Professor Hill stated that it is better to use a chisel instead of a plough. Professor Hill, do you not think it would be more costly and time-consuming to proceed in that manner on a large piece of land?

Professor Hill: I think there are two aspects to this question, senator. One is that there are times when one needs to use something like a moldboard plough. When you are breaking new ground, it is much easier to use a moldboard plough to break that ground. When the soil is not that fertile and is compacted, it cuts up more easily than it would under a chisel plough and a disc. However, if each farmer pays attention to the soil and starts to build it up, these organisms that I have been talking about will basically do most of the cultivation for him. It therefore becomes easier and easier to cultivate the soil and the farmer needs a smaller and smaller tractor to pull the plough. On the other hand, with our conventional approach to soil management, history has shown that we need a bigger and bigger tractor, which compacts the soil more and more. This means that we then have to use yet a bigger tractor and the whole thing is a destructive cycle.

Senator Lapointe: What do you mean by "urban waste?"

Professor Hill: Urban waste would be the organic waste from bringing all of the food materials to the city; basically it is the stuff that we flush down the toilet.

Senator Lapointe: You are saying that it should not include oil and substances like that?

Professor Hill: No, it needs to be made up of material that is not poisonous. That is the problem we face with urban waste. We mix it up with materials that are poisonous so that we need to separate those wastes that can be returned to the soil from those that cannot.

In Quebec we have a policy of producing our own animal food. We transport grains across the prairies from the west in order to feed the animals in the east. This removes the organic materials from the land in the west, thereby degrading the soil and enriching the soil in the east to the point where we cannot manage the waste and it gets dumped in the river. We end up with pollution. If I were to propose that the solution to this problem is to truck the manure from Quebec back to the west, everybody would think I was crazy. Maybe I am. In a sense, however, the implication is that, eventually, we need to have a much more regionally self-reliant system of population distribution.

Perhaps we could ask ourselves this question: If we were really serious about solving this problem, what would we do? Would we distribute the population in the same way it is now distributed? No, we would not. If we had millions of dollars to spend in solving this problem, we would go and solve it. If each of us expected to live for 2,000 years, would we continue to treat the soil the way we treat it now? We would not poison the soil in that case.

Eventually we have to wake up and begin to look at these things seriously. I am glad that this committee is studying the problem of soil erosion. I hope that honourable senators will continue to look at the problem at its causal and fundamental level.

The Acting Chairman: Thank you, Professor Hill. You have given us a lively presentation on a lively subject.

Professor Hill: Thank you.