ECOSYSTEM RESTORATION:
A SYSTEMS APPROACH TO EXOTIC PLANT CONTROL

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Ecosystem restoration is a systems approach because it relates to all of the thousands of interrelated and interacting systems within the ecosystem. Ecosystem restoration also changes your role in the forest from observer to participant. Some of the goals of ecosystem restoration are to improve the health, vigor, and diversity of the ecosystem—and these goals can and must be quantitatively measured. The concepts and processes of ecosystem restoration will be illustrated by a specific example with an emphasis on the application and methods of prescribed burn, which can be very useful in the control of exotic pest plants.

INTRODUCTION

Many of you are under a mandate to provide a regular supply of timber products and may be wondering how ecosystem restoration relates to your situation. Some of you may be under a mandate **not** to interfere with the forest except to remove the exotic pest plants and may be wondering how ecosystem restoration relates to your situation. Some of you may be operating under a belief system that says, "If we get rid of all the exotic pest plants in the forest, then the forest will take care of itself and will not need people." I am asking all of you to briefly accept that you are part of nature, and that you are obligated to be a nurturing participant in the forest. You may find some useful ideas in this discussion of ecosystem restoration. Some of what you now know may be challenged by these ideas about ecosystem restoration.

PERCEIVING THE NEED TO RESTORE

Perceiving the need to restore requires a combination of the ability to see the forest clearly, without prior assumptions, and a belief system that will allow you to be a nurturing participant in the forest. For this reason, it is useful to me to think in terms that include people as part of nature. In this paper, I refer to them as two distinct and separate entities. Therefore, I will use the term "the rest of nature" to mean all living and nonliving things in the universe **except** people.

Our culture, and thus, our educational system, teaches that people can only have a negative effect on "the rest of nature." Nearly all ecologists describe the original ecosystems—meaning the ones that the first Europeans found here—in terms of "the rest of nature" and almost always disregard as insignificant the activities of the indigenous people that were present. This viewpoint does not take into account the effect of 20 million or more indigenous people who both occupied and actively cared for the "Garden of Eden" which the settlers first found (Anderson 1997, Martinez 1996, Olson 1996, and Cronon 1983). This belief system does not help us to understand how we can recreate that

"Garden of Eden." Again, please accept, at least for the moment, that people can be nurturing and have a positive influence on "the rest of nature."

With these ideas in mind, I looked at the forests in the Brecksville Reservation of the Cleveland Metroparks, Ohio. I discovered that unhampered by the aforementioned assumptions and enabled by a belief system that allows me to be a nurturing participant in the forest, I could see the need to restore this forest. I could see the decline in vigor of the even age oaks in the canopy, of the understory oak forest components, and even of all members of the herbaceous layer. In addition, the second age class of white oaks did not find space in the canopy and died due to the lack of proper light.

WRITING A QUANTITATIVE BEHAVIORAL STANDARD

Once you have perceived the need to restore, your next step is to write a quantitative behavioral standard (QBS) to guide you in your restoration efforts. Having determined why the forest is unhealthy, you simply write a description of how it will be when it is healthy and this becomes the QBS. QBS is a term which I coined specifically to measure progress in the restoration process. In our example of the Brecksville Reservation, the forest is overstocked (Ginrich 1967). This means that there are too many trees and too many square feet of basal area of trees per acre to have fully healthy oak trees. So, the QBS in this case would be: *At least 75% of the species on the list of oak-hickory forest ecosystem indicator species will set seed at least once in every five years.* The restorative effort will be to reduce the stocking percentage from the current 120% down to 70% and monitor the changes in the ecosystem. The reduction of stocking percentage will also make space in the canopy for a second age class of white oak.

Note that the QBS is quantitative. It contains measurable numbers. It is behavioral because you are measuring changes in the behavior of plants. It is also a standard—which means that it can be "held up" to the existing forest to see if you are moving toward or have reached the stated goals. Another characteristic of a QBS is that a knowledgeable person with a day or less of training can perform measurements to determine the forest's progress toward the specified standard. The QBS is not limited in its quantitative standards—it can relate to percentage of flowering, seed setting, and production of offspring; number of nesting birds; breeding salamanders; etc. But, it must define measurable quantities—to say "the forest is doing better" means nothing. You can and must quantitatively define what "better" means, by translating it into a QBS.

It is often helpful to have a reference ecosystem on which to model your QBS. In the example of the Cleveland Metroparks forest, I used the original land survey which was conducted in 1811 for the Brecksville township. Sometimes a nearby forest may be a useful model. A careful study of the types and quality of ecosystems in the area in which you are working is most useful. A recognized reference, such as *The Vegetation of Wisconsin* (Curtis 1959), is useful well beyond the state of Wisconsin because it examines regional forest types, fully characterizing their plant associations.

PLANNING THE RESTORATIVE EFFORTS

Because this forest had very low vigor in all layers, (i.e., the canopy and oak forest components of the understory and herbaceous layer), the restorative efforts were aimed at increasing vigor of all

layers. Therefore, one part of the QBS stated: *White oak and shagbark hickory will produce seedlings more than once every 15 years.* In order to achieve this, restorative efforts were targeted at reducing the stocking percentage of the oak. The intent was to improve the health of the individual trees, thereby increasing their ability to produce viable acorns. Enough acorns need to be produced so that some would remain after predation to produce seedlings. The restorative efforts were designed to reduce the stocking level from the current 120% down to 70%—with the target number based on Gingrich's study of oak tree health (Gingrich 1967). In practical terms, this means that 103 trees, averaging 13 inches in diameter, were cut on 2.5 acres. This opened up space in the canopy for the second generation of oak trees. This reduced the percentage of canopy to well less than the 85% needed for white oak regeneration (Curtis 1959).

Another part of the restorative effort focused on the understory of this oak-hickory forest. Sugar maple had become pervasive in the understory, supressing the growth of other woody and herbaceous species present. This great increase in sugar maple, as compared to its frequency at the time of the original land survey, has been well documented (Ebinger 1986). This pervasive sugar maple growth was limiting the amount of Photosynthetic Active Radiation (PAR) reaching the forest floor. PAR is defined specifically as wavelengths between 400 to 700 nanometers, and is the critical segment of the sun's light spectrum which plants require to be able to conduct photosynthesis (Attridge 1990). It is possible to have light reaching the forest floor, but if it does not include the PAR segment in the proper amounts, then the plants are essentially in the "dark." Herbaceous plants or seedlings of the forest floor must likewise receive adequate PAR in order to flower and seed. Therefore, another part of the restorative effort was to remove the sugar maple understory, using prescribed burning and cutting. Together, these actions were intended to meet the specified QBS of 75% flowering of the oak-hickory forest species, as stated above.

The declining condition of the forest, the QBS, and the restorative efforts are interrelated as follows: Inverting the conditions which you want to change in the forest defines the QBS and the restorative efforts are the means by which you bring about the desired changes and achieve the QBS. The end result of using the QBS method is that you are assured that you have measurably succeeded in "curing" what is wrong with the forest.

DESIGNING A MONITORING SYSTEM

In monitoring progress of the Brecksville restoration, we used 91 sets of stratified random quadrats, with three quadrats per set. In a 0.01 hectare circle, trees are measured and identified every three years. In a 4 x 4 meter quadrat, all woody stems under 6 inches are measured and identified and mayapple are monitored. In a 1 x 1 meter quadrat all herbaceous plants are monitored and acorn counts are made. The 4 x 4 and 1 x 1 quadrats are monitored often during each growing season. Other data are also collected on these quadrats. Forms were developed so that all data were properly collected and all data are entered into a Paradox-based database.

DATA COLLECTION

Volunteer Earth Restorers established most of the quadrats and have done over 90% of the data collection in the Brecksville Reservation. These volunteers have done an excellent job. Please do

not think of volunteers as "children of a lesser god." The fact that they are not paid for what they do does not mean that it must be of lesser quality (Smith 1991 and 1995).

IMPLEMENTING THE RESTORATIVE EFFORTS

As a practitioner, the implementation is the exciting part. However, without first developing the QBS and a monitoring progam, you will never know where you are going in the restoration process. Or, as it says in Alice in Wonderland, **"If you do not know where you are going, any road will get you there."** The order in which we implemented the restorative efforts in Brecksville were: (1) prescribed burn, (2) understory removal of the sugar maple and beech, and (3) canopy opening, i.e., describing the stocking rate. Separate areas were treated with different restorative programs as follows: (1) burn only, (2) burn and cutting of the understory only; or (3) burn, understory cutting, and canopy opening. The monitoring of these differing treatments enabled the evaluation of each restorative effort. Since cutting of trees and saplings is easy to understand, I will not cover it in this paper, and will instead go into prescribed burning in some detail.

Another part of the QBS stated that: *Non-native, exotic species will constitute less than 10 percent of the total above-ground stems*. The main restorative effort that we used to meet the exotic pest plants elimination goal of the QBS and to begin understory removal was prescribed burning. Prescribed burning is defined as fire (1) applied in a skillful manner, (2) under exacting weather conditions, (3) in a definite location, (4) for a specific purpose, and (5) to achieve certain results. By monitoring after a small prescribed burn, we determined that the certain results that we could obtain were to kill about 90% of all the above-ground stems of 2 inches or less in diameter of all species without damage to trees or herbaceous plants. We burned when all species were dormant.

The burn window that we always used was:

wind direction	any
wind velocity	less than 3 miles per hour in the forest at eye level (which means that no leaves are changing location)
relative humidity	30-55% (35-45% preferred)
temperature	32-65 F (Dixon et al 1989)
fuel moisture	Pass the "bucket test" – see below (Moore 1991)

The bucket test consists of simply picking up a small portion of all the leaf layers intact, placing them in a metal bucket, taking a leaf from the top layer, lighting it, and dropping it into the bucket. What is left in the bucket after the fire is similar to what will be left in the forest after the fire. If there are two layers of leaves left in the bucket, then there will be two layers of leaves left in the forest. Often it is necessary to do the bucket test in different moisture situations in different parts of the forest to get an accurate picture of what will happen. The "bucket test" allows you plan burns that leave leaf litter or remove it all, depending on the prescription and reason for burning.

A few points need to be kept in mind when planning a prescribed burn. First, a prescribed burn will top kill ALL above-ground stems that are 2 inches or smaller in diameter. Yes, that includes honeysuckles, buckthorn, and so on. Second, always remember that weather controls a fire, NOT

people. All people can do is plan and ignite a fire so that weather will control it. In almost twenty years as fire boss, burning forests and tallgrass prairies, we have never had any injuries. We burned only what we planned to burn and achieved the results that we expected. Finally, please be aware that many states and agencies have a certification or licensing requirement before you are allowed to conduct a prescribed burn.

HERBACEOUS LAYER ENHANCEMENT

In a study that was done in England, it was clear that adding herbaccous species as plants maximized survival rate, but it is costly and very labor-intensive. Use of seed came in a close second and has the important advantage of lower cost and less labor (Francis 1995). In this study, the important factor was seeding or planting in bare soil. My own studies have indicated the same. When you think about putting small seed on leaf litter or under leaf litter, you know that the seed does not have enough stored food to either get a radicle down to soil or shoot up through the leaf litter. Prescribed burning was used to remove the leaf litter in our study.

THE STRUCTURAL HEALTH OF THE SOIL

Just as a reminder, you need to pay very careful attention to avoid compacting the soil or interfering in any way with the functioning of the soil microbes or mycorrhizal fungi. Without passages in the soil for air and water to go into the soil and carbon dioxide to come out, the plants will not be healthy (Harris 1996).

EVALUATING RESTORATIVE EFFORTS

This is the simplest part. You can compare the first year of data with the second and successive years' data and see if you are moving in a direction that will enable you to meet the goals outlined in your QBS. Be aware that there may be some ups and downs in the progress of the restoration. If you find that you are not accomplishing the QBS, you may need to reevaluate your restorative efforts. Remember though, change is not sudden in a forest.

CONCLUSIONS

I hope each of you has found something useful in this brief discussion of forest ecosystem restoration. For those of you that are mandated to provide a regular supply of timber products, you may find it interesting that this mandate can fit in with ecological restoration. The Chief Forester of the Ohio Department of Natural Resources has outlined this idea as follows: If we can thin the stand (which is also called reducing the stocking percentage) of an oak forest and reliably get a second age class of oak, we can revolutionize the gathering of timber products because we can harvest trees and not the forest. For those of you that are mandated not to interfere with the forest, except to remove exotic pest plants, you may have found useful ideas that can help you modify that mandate. For those of you that operate under the belief system that says the forest does not need nurturing people, perhaps this discussion has challenged that belief system enough that you are now a little uncomfortable with it. Perhaps you will try being nurturing to the forest and see how it goes for you and the forest. I feel better about me when I am being nurturing to both forests and people.

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