Interdisciplinary Breakdown in Landscape Restoration*

by

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Abstract: Restoring degraded landsites to biologically balanced landscapes has become an important focus for landscape/planning firms, utility companies, natural resource management agencies and other organizations that must adhere to federal and state environmental mandates. Wetland revegetation, mining reclamation, highway roadside revegetation, reforestation, and other ecological projects have specific planning, design, and construction requirements with emphasis on use of wild stock. These requirements are often far different from standard ornamental planting practices. Developing contract documents for landscape restoration projects causes problems for both the contracting ecological planning firms and for the horticulturists that provide wild-stock. The American Standard for Nursery Stock (American Association of Nurserymen, 1990) is the most widely accepted industry document that describes the minimum standards for providing plant stock to the landscape industry. All the organizations mentioned above utilize the guidelines laid out in the standards document to judge if plant material supplied by a nursery is acceptable. This raises many problems for restoration projects. For example, wetland relocation projects require plant material that must be collected within the vicinity of the restoration site, the time line for collection or propagation of material is often less predictable than typical ornamental stock. Issues of survivability, genetic resource preservation, and community plant palette selections further complicate the design, supply, and construction process. There is no guidance for nurseries or natural resource agencies which are being called upon to design, install, and monitor landscape restoration projects.

Landscape organizations are typically awarded a contract for a restoration project. They do research, design a final plan, and draft the contract documents and planting plans. Nursery providers are then given the required plant lists with only a few weeks lead time to locate the order which may be for many diverse native species. Propagation of large orders is almost impossible. Out of necessity, nurseries may choose to collect from the wild or hire plant collectors to fill the order. No training is required to be a plant collector. Almost anyone who can access a shovel or other excavation equipment can become a plant collector. In contrast, landscape restoration requires a wide range of skills and education. A set of illustrated guidelines and commonly accepted practices could help promote the two most important ecological principles. First, that wild plant communities used for collection must be left intact, and second, that new plant communities installed on a restored landscape must

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be biologically balanced and able to stabilize a site, to preserve and create habitat.

Introduction

The need for research, documentation, and guidance in conducting restoration projects has become an important topic among related disciplines. At a Rare Plant Consortium meeting (Central Washington University, Ellensburg, WA, May 2, 1992), growers, collectors, and landscape architects met to address the problem of lack of communication among these industries that are dependant upon one another. Native plant growers and collectors, ecological designers and contractors all need guidance on preferred techniques for plant ordering and about installations that help assure greater rates of plant survival. Guidelines are needed to promote the use of techniques that have lesser impact on the landscape during the process of collection, propagation systems that include ecological evaluation of plant materials, and use of environmentally sound installation practices.

Restoration and Reclamation vs Ornamental Planting of Native Species

A wide range of opportunity currently exists related to working with native plants. The term "restoration" actually refers to a broad class of conservation work involving the creation or re-creation of whole plant communities and ecosytems. Restoration thus includes elements of revegetation, reintroduction, and introduction of particular species, woven together into an integrated whole (Jordan, 1986, Faulk, 1987). Ecological restoration, then means to bring back into a prior condition an ecological system such as a landscape.

> "Reclamation commonly refers to work carried out on severely degraded sites such as surface-mined areas. By these definitions, reclamation and restoration are not separate processes, but different phases of an overall process that begins with reclamation and culminates - when appropriate - in restoration. This in turn would suggest that reclamationists and restorationists would best work closely together, with reclamationists, specializing in soils, hydrology, toxics reduction and so forth, laying the groundwork for further ecological upgrading by restorationists. Unfortunately, however, this is not usually the way things work out. Instead, reclamation and restoration have emerged as two more or less distinct initiatives. They are represented by separate organizations with few

members in common." (Jordan, 1992, p. 14).

Native plants are often used ornamentally rather than for restoration, meaning that the newly created system is not biologically balanced. Frequently, artificial structures, such as irrigation are necessary for the plants to be viable. An example of a large project that is designed to look natural, but that in fact is quite artificial in its sustainability, is the Metro Project in Discovery Park, Seattle (Sullivan, 1992). Under the planted surface the park is filled with reinforcement structures, pipes, and irrigation, however, all native species were used to meet certain project objectives. This project represented a large plant production bid to the native plant nurseries in the Seattle area.

Projects whose objectives are to re-create whole plant communities upon a site require different planting specifications than those projects that use native plants ornamentally. Scientific information such as plant genetics becomes important in restoration. The physiographic features of the site where the plants originated and using local genotypes should be issues of great concern. The use of the plant materials often are not known or considered by nurseries. There is seldom differentiation between ornamental uses and ecological applications on the part of the nursery unless specific objectives are delineated by an interdisciplinary team of scientists and designers. Nurseries commonly contract the propagation and growing of seed or cuttings from a site that is scheduled for alteration or restoration. The California State Park System has developed guidelines for commercial nurseries.

> "If a commercial operation collects the plants for revegetation, requirements for proceedures, labeling and record-keeping should be clearly specified. The (Park) Department should prescribe the sampling and handling procedures, and monitor compliance. Both the appropriate range of collection sites and the propagule type should be determined for each species in the palatte. Since significant variation can occur over short distances, guidelines based on geographic distance are not reliable. Collections in the near vicinity of the restoration site are preferred. When adequate numbers of donors are not available on site, additional collection sites should be identified" (Guinon, 1992, p.13).

Record keeping is specifically mentioned in several portions of the California State Park System document. However, enforcement for such practices is the responsiblity of the Parks.

> "The genetic origin of the propagule should be safe-guarded with

conscientious labeling, storage and handling. Labels should record the species, date of collection, and donor location" (Guinon, 1992, p. 15).

Case Studies

Restoration professionals acknowledge that little guidance exists in the literature for related professions working on restoration projects. Other than case studies, which are useful learning tools, there is a derth of information about accepted practices. Based upon this observation, a resource review using these professionals' experiences was used to identify common issues associated with landscape restoration projects. Since a literature review revealed very little information about how to successfully use an interdisciplinary approach to landscape restoration projects, a resource review was used in the qualitative study. The methodology was a telephone interview process. Included were private landscape design and planning firms, independent growers, and staff members of government agencies such as the Bureau of Land Management and the National Forest Service. The primary objectives of the telephone interviews were to supplement facts previously gathered from observations made about current landscape restoration practices and to facilitate the development of a survey to address pertinent needs in the native plant industry. A secondary objective of doing the telephone interviews was to heighten the sense of participation in the research by involving key members of the industry at the beginning of a research process (Jones, 1973). During the interviews the people working at various tasks of native plant projects were asked to explain their perspective regarding the process of accomplishing restoration contract projects. The following questions were asked each interviewee:

1.) What were some of the successful projects that you have been involved with and why were they successful?

2.) What were some of the more difficult restoration projects and what were the problems?

3.) If a set of recommended restoration practices were written, what information do you feel should be included?

The qualitative analysis that follows synthesizes the telephone discussions by professional group. Where agreement or consistency of thought was found, a general discussion is given Examples from the interviewee responses are used to back up the points of agreement between interviewees.

Landscape Architect

The contracting process involves standard procedures that allow for negotiations to best meet the project objectives.

1.) A request for proposals for bids is advertised to landscape design and contracting firms.

2.) A landscape architecture (LA) firm submits preliminary estimates for costs to the agency responsible for the project.

3.) The agency selects a bidder based on the announced rating process.

4.) Once the contract is awarded, the successful LA firm draws the plans and all necessary contract documents (site plans, planting plans, construction and planting details, specifications for installation, ordering, delivery of material, and monitoring requirements).

5.) Subcontract proposals are put out for bid to suppliers of plant material and subcontracts are made with the nursery growers and construction contractors.

6.) Pre-contract and construction meetings occur as needed so that any concerns which includes growing or collecting plant material can be negotiated and resolved before the construction process begins.

Problems often arise when contract documents do not state who is responsible for what portions of the project. Lawyers are consulted which raises the price of a project. A common concern voiced by all interviewees was that lawyers tend to write construction contracts so that they protect the client who hired them, and not to guarantee the overall success of the project. The objective of the LA firm is to write specifications that are clear and that include realistic standards. Project coordination is a critical function of the LA firm. The firm relies upon the expertise of specialists, but in most projects they are responsible for design, project schedules with subcontractors, and coordinating financing.

Traditionally, landscape architecture degree programs teach landscape design from an ornamental perspective. Horticultural applications of plants are the standard and proper installation and maintenance is stressed. Classes are also required in natural resource planning and management, mostly on regional levels, such as watershed planning. Additionally, construction and project contracting is taught as part of professional practice. The skills of project coordination and design are becoming recognized as important skills in landscape restoration projects. The educational curriculums are beginning to reflect stronger emphasis in natural resource design as a part of planning and management.

Recognizing that LAs have previously been involved in development work, it is logical that they should also be involved in the use of ecologically sound practices for landscape restoration work. Many of the practices that are being experimented with in landscape restoration involve a mixture of construction management, agricultural engineering, horticulture, design, and biology.

One of the design team members for the Metro Project stated, "Biologists and natural resource specialists represent the biological side. The design side must be addressed also. Danger in restoration projects is when the project becomes one-sided. There is a need for well coordinated interdisciplinary approaches to restoration projects," (Harding, 1992). An example of a poorly coordinated project is one which was done in California. One of the objectives was to create a song bird habitat. A botanist was hired to design a 50 foot x 50 foot sample planting plan. The natural resource managers in charge of the project accepted the plan and wrote the specifications to replicate the 50 cubic foot planting plan across a 10 acre area. This is hardly the distribution of a natural setting. In the process of providing habitat to the song birds, they failed to regard opportunities for habitat for other animals. They also failed to recreate a site that looked like a natural distribution of plants according to the changes in site undulations, and micro climates.

Obtaining native plant material for Washington projects is problematic. There are shortages at the nurseries and orders are often filled with substitute material or by nurseries outside the region. Project schedules frequently do not allow enough time for plant propagation. For example, one landscape architect estimated that an order of 175,000 small plants required only one growing season and that a single nursery should be expected to hold the collected wild plants for approximately 10 months before moving it to a project site. In most cases, a nursery could not meet this schedule and the plant health would be at risk. Another set of specifications called for 2,000, four foot *Pseudotsuga menezisii* (Douglas firs) and 3,000, four foot *Thuja plicata* (western red cedar). The LA assumed that the order would be filled through a mixture of cuttings and seedlings. The plant origin was not a concern. Frequently contracts are filled through large nurseries located in other parts of the country. Information about the site characteristics or where the plants originated is not a concern. The species and conditions listed in the specifications are the only requirements.

There is an attitude and perception that, "time is money" reflected in contruction and development projects that are driven by financing, sales and returns on investment. On the contrary, restoration benefits from trying to replicate natural processes over financial gains. Longer research time and planning is often needed for restoration than projects associated with a built environment.

The production attitude regarding project success is short sighted for at least two reasons. It does not consider longevity of the plants' survival or the impact upon the existing plant communities. Also, lack of concern about supporting the local economy and the local nursery market was evident. On the other side of the argument, the nursery industry has not been able to keep up with the increased demand for native plant material.

Poor handling practices by contractors installing the plants was mentioned as a common concern. Often plants were handeled with little regard to root damage or branch breakage. Large material that was dug, frequently was moved several times before being permanently installed. Plants were set back a full growing season or more depending on primordial growth patterns and time of transplanting. Soil planting interfaces were also mentioned. Matching soil conditions was seldom given adequate assessment before installation.

The LAs who were interviewed agreed that restoration projects must incorporate a team approach. Different areas of expertise are needed to fully understand the complexity of natural processes. The LAs consider their role to be in design, project coordination and implementation. They consult with scientists, growers, and contractors so that the project is designed for appropriate specie selection, plant installation, and creating a natural appearing site. These are the skills they bring to the project. LAs have limited training and understanding of biologic community structure. They must rely upon specialists such as biologists, and growers for their expertise in any restoration project.

Nursery Growers

There are several problematic areas for growers dealing with native plants. When projects call for four foot native trees species, growers can not afford to grow them from seed or seedlings for approximately four years without a contract assurance for purchase at a certain date. When a project calls for 1,000 *Psuedotsuga menzisii* (Douglas firs) and the growing window is one year long, it is quite probable that the material was not grown in the nursery, but was instead dug or purchased from plant collectors. One season for reestablishment is not an acceptable standard according to the American Association of Nurserymen (ANN, 1990).

> "It is generally recognized that plants growing in their native state will sustain a much more severe shock when transplanted than the same kinds of plants when nursery grown. If collected material is moved, a considerably larger ball than that recommended for transplanted nursery stock is required, because of the unrestricted root development and the

varying conditions of soil in which such material is found. . . "

"Trees collected from wild or native stands may be considered nursery grown when they have been successfully re-established in the nursery row and gown under regular nursery cultural practices for a minimum of two growing seasons and have attained adequate root and top growth to indicate full recovery from transplanting into the nursery row," (p.6).

Growers have difficulty with the AAN standards when working with native plants. From a biological and ecological perspective, the AAN standards often do not apply. For example, height and caliper of a plant has no relationship to vitality and root spread and has no relationship to the health of the plant. Typically, however, requests for native plant bids on specifications call for ". . . grown to AAN Standards." The experience of Dan McKane (1992), a native plant collector and grower, is that when native stock is bid according to the AAN Standards, the bids are notoriously higher than if they had been calculated based upon the criteria of plant health and vigor.

One grower stated that typically bids for large agency projects are 30 - 40% higher because large agencies are less flexible with the plant specifications and the lack of flexibility causes unnecessary extra work for a nursery. A Washington State Department of Transportation highway revegetation project on Mercer Island called for a large order of 15 inch - 18 inch tall *Rhus typhina* (staghorn sumac). The nursery collected starts from local species, propagated and grew the plants for two seasons. The project was delayed another year and when the nursery was called to deliver the plants they were a robust 24 inch in height. The on site project inspector would not accept the plants at that height because they would not meet project specifications. Though they would more quickly achieve a full planting with the 24 inch plants which had larger root systems than smaller plants the inspector felt bound to a literal interpretation of the specifications. Because the plants did not meet specifications, there were two options for the grower. One was to try and sell the 24 inch material to another project (for which there was no contract) or to transport the plants back to the nursery, prune them to 18 inch then truck them back to the Mercer Island project which was an added expense to the business. In this instance, a person who was knowledgeable about plant material was needed to inspect the plants and make a reasonable judgement. Another approach would have been to incorporate more flexibility into the writing of the plant specifications document.

Another concern of environmentally aware collectors and growers is that large agencies who

provide the market for native plant material have not taken measures to control or regulate plant collecting. There is no license for collecting plant materials, no taxes are placed on sales, and because of increasing demand, it is becoming a black market. Fred Hopkins, of Warm Beach Nursery (1992) estimates that he receives more than one plant collector per week coming to his nursery to sell plants out of the back of a pickup. Most of the plants are *Pseudotsuga menzisii* (Douglas fir), *Acer circinatum* (vine maple), and *Populus tremuloides* (quaking aspen) (Hopkins, 1992). Plant poaching has begun to take on aspects of animal poaching. One grower reported that he felt threatened when he witnessed collectors who did not have permits and who were armed with rifles on a collecting expedition. Legitimate collectors who do pay for permits from the National Forest Service may find that by the time they get to their plots, they are too late, the plots have been illegally harvested.

Digging season for native plant material starts about October and by February the yards of plant collectors are fully stocked for sale for the coming season. Material is seldom held for the two growing seasons, required for native material by AAN standards. It is the growers who must assure that the plants have been re-established into the nursery row before they are moved for a third or fourth time prior to installation though records are seldom maintained on plant progress.

Giving priority to purchases of plant materials within the state is one way to circulate dollars one more time which is a basic principle for economic restructuring in small towns across America (Cook and Bentley, 1985). One nursery thought that state agencies across the country should give priority in bidding to local in-state businesses.

Progress payments are one strategy for helping nurseries with cash flow during the propagation phase of large orders of native material. One payment schedule commonly used by John Folkerts, from Reed Collins Nursery in British Columbia, Canada, is for the nursery to be paid 35% of the order upon contract award. Half way through the project the nursery receives another 25% based upon how much of the material has survived and is healthy. At the end of the project, once all the material is delivered, the remaining 40% of the order is paid. This method equally distributes the investment of material to both sides at various intervals of propagation (Folkerts, 1992).

Public Agencies

Washington State passed the 1990 Growth Management Act. The intentions of the act are to preserve the natural heritage and resources of Washington. Frequently, city and county codes are promoting the use of native plants for local government projects. A result of this has been an increased use of native materials in urban fringe growth areas. The nursery industry can not keep up with the demand for natives. Large nurseries often must buy materials from anyone who comes to their door to sell collected

plants. There is little awareness or concern about where the plants originated, what type of site they grew upon before collection, or how the material was obtained. Nurseries are not required to keep records about native collected materials. The state and federal agencies have the power to impose control over unethical and unecological practices by requiring records and more information on the plant materials they use. Further, in Washington State the nursery inspection law treats the transport of native plants as other ornamental species. Most businesses, such as restaurants, are regularly inspected for practices of health, safety, and welfare of the citizens. The USDA inspects for pests and improperly labeled plant materials, but it has no requirements for plant origin which when mismatched can be directly linked to delayed plant death (Millar and Libby, 1989).

There are economic and ecological benefits for state agencies to become involved with regulating native plant collection. Since the trend of state regulations is to encouraged use of native species, ecologically, the policy should require that the plants be from native origins to protect local genotypes. Research has shown that "the genetic nature of introduced stock can profoundly influence the behavior of the individuals, which in turn may affect the dynamics of the entire community," (Millar and Libby, 1989).

National Forest Service:

Collection of native plant material in the National Forests falls into the category of "special forest products (SFP)." Permits are issued for the purpose of selectively harvesting seedlings and small trees. Each district has staff assigned to special forest products, but guidelines for monitoring depend upon individual districts. There are progressive monitoring programs that have guidelines which require refilling of holes where material has been removed and replacing forest duff so that it is nearly impossible to tell a harvest has occured (Rassbach, 1992). There are also many non-progressive SFP programs that simply issue permits and that do not monitor collection sites.

According to Millar and Libby (1989), the forestry profession has a long history of restoration in planting or seeding to reestablish forests after logging, fire, or other catastrophic devastation. There are two points of agreement between geneticists and foresters.

> "1. With few exceptions, species are genetically structured and, in most, the patterns of their genetic structure are hierarchical. By this we mean that the total genetic variation in a species is organized and can be described as variation among physiographic regions, variation among stands or populations within regions, variation among families, (kinship groups) within stands, and

variation among siblings within families.

2. The patterns of variation can often be understood to reflect adaptations of the trees to their unique environments in which ancestral populations have evolved. It is important for restorationists to understand that each species they introduce will have such genetic patterning and specific adaptation. If they are to recreate native communities, the genetic structure should be replicated, for this will allow the greatest potential for the introductions to survive over the long time period. Knowledge of the hierarchical nature of variation allows the restorationist to select the genetically most appropriate material, even when collecting from within the restoration site," (p. 5).

The National Forest Service (NSF) does not know what level of plant community destruction is happening in the forests in Washington State (Potashum, 1992). The funds generated from the sale of SFP are small and at current rates would not fund an extensive monitoring program. Based on informal observation by staff issuing SFP permits, demands for native plant permits has increased in the last five years (Rassbach, 1992). NSF is attempting to access the ecological ramifications for providing native plant material as a resource.

Bureau of Land Management:

The Spokane District Office of the Bureau of Land Management (BLM) is actively pursuing land exchanges with ranchers in Washington State for the purpose of restoration. A majority of the plant material that they order is native grass seed, though concern was expressed that in native seed orders, none of the local flowers are included. There is a need for more diversity in forbes and shrubs on many of the projects. They have had problems locating local genotypes of *Agropyron spicatum* (bluebunch wheatgrass and Festuca idahoensis (Idaho fescue). The BLM has a permiting process for collecting native plants and is trying to move in the direction of requiring records from contracting nurseries. The BLM is concerned about reinstallation of locally collected plant material onto the overgrazed landscapes.

The BLM Spokane District Office reported a shortage of local genotypes of plant material. They acknowledged that they need to work more closely with growers to assure availability of material. On a recent project along the drainages of Crab Creek near Othello, Washington, a restoration plan called for *Prunus virginiana* (common chokecherry) which usually was available from Plants of the Wild Nursery in Tekoa, Washington. The

nursery was out of the stock because it filled an order for the NFS in New Mexico. Another nursery in Bonners Ferry, Idaho was contacted and the common chokecherry was purchased during the winter and installed on the site in the early spring. The plants eventually leafed out to the purple cultivar 'Schubert.' Because of mislabeling of material there was no way to determine this when it was not in leaf. The BLM botanists have plans to move the purple leaf trees to a new location where they will be used in an ornamental manner (Aldridge, 1992).

The BLM would like to see more information and guidance on establishment methods for restoration projects. These methods could include community seeding planting for survival, soils, and moisture regimes. The BLM often tries using agricultural methodology, but are not assured that native species will perform similarly to horticultural materials.

There is a BLM monitoring program, but it is based upon visual field checking for a few years after the project is implemented. Plots are not replicated or statistically recorded. There is no money to do scientific monitoring because the BLM is an applied land management program and not a scientific research program. The BLM relies upon research institutions such as universities for guidance and contracts for monitoring.

Summary

A good field biologist is often more concerned with what is missing in a situation than with what is present (Soule, 1986). Similarly, many professions involved in landscape restoration are becoming increasingly concerned with the gaps in the restoration process. A communication gap exists among all the disciplines involved in restoration projects. Many issues between designers, growers and ecologists have surfaced and need to be addressed by research. Each restoration project has an element of experimentation and difficulty in replication, but a need exists for guidance and documentation about accepted practices for many aspects of restoration.

Ecological design competence means incorporating intelligence about how nature works into the way we design, build, and live (Wann, 1990). Restoration as a part of ecological design requires getting beyond the boxes we call disciplines to see things in their larger context (Orr, 1992). There is a need to draw upon experience gained from past restoration projects and offer guidance for future endeavors.

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* Publication in this proceeding does not preclude author from publishing this manuscript, whole or in part, in other publications.

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References

Aldridge, Anne. 1992. Bureau of Land Management. Spokane District Office. Telephone Interview.

American Association of Nurserymen. 1990. American Standards for Nursery Stock. Washington, D.C. Technical Document ANSI Z60. 1: pp.33

Cook, Edward A., and Bentley, Marion T. 1985. Revitalizing the Small Town Mainstreet. In Hard Times: Communities in Transition. Miscelaneous publication from the Western Rural Development Center, Oregon State University, Corvallis, Oregon. pp. 1-11.

Faulk, Donald A. 1987. Integrated Conservation Strategies for Endangered Plants. Natural Areas Journal. Vol. 7(3): pp.121.

Folkerts, John. 1992. Reid Collins Nursery, British Columbia, Canada. Telephone Interview.

Guinon, Marylee. 1992. Guidelines for Management of Genetic Resources in the California State Park System. Sycamore Associates for the California Department of Parks and Recreation. pp. 13-15.

Harding, Robert. 1992. Dale Evans and Associates Landscape Architects, Seattle, Washington. Telephone Interview.

Hopkins, Fred 1992. Warm Beach Nursery. Stanwood, Washington. Telephone Interview.

Jones, John. E. 1973. The Sensing Interview. Annual Handbook for Group Facilitators. University Associates, San Diego, CA. pp 213.

Jordan, William R. III. 1986. Restoration and Reentry to Nature. Orion 5(2): 14-25. https://doi.org/10.3368/er.4.1.2

Jordan, William R. III, 1992. Those RE-Words: A Glossary and a Few Comments. Land and Water Magazine. Nov/Dec.

McKane, Daniel. 1992. Stormlight Growers. Woodenville, Washington. Telephone Interview.

Millar, Constance I. and Libby, William J. 1989. Restoration: Disneyland or Native Ecosystem? A Question of Genetics. Restoration Management Notes. Vol 7, No. 1. pp. 3-10.

Orr, David. W. 1992. Education and the Ecological Design Arts. Conservation Biology. Vol. 6. No. 2: pp. 162-163. http://dx.doi.org/10.1046/j.1523-1739.1992.620162.x

Potashum, Laura. 1992. Mount Baker Snoqualmie National Forest District Office. Telephone Interview.

Rassbach. Michael. 1992. National Forest Service Western Regional Office, Portland, Oregon. Telephone Interview.

Soule, Michael E. 1986. Conservation Biology. Sinauer Associates Inc. Publishers. Sunderland, Massachusettes. pp. 1-3.

Sullivan, Linda. 1992. Metro West Point Project, Seattle, Washington. Telephone Interview.

Wann, D. 1990. Biologic: Environmental Protection by Design. Johnson Publishers. Boulder, Colorado. pp. 284.