Aspects of the Form, Ecological Function and Aesthetics of Garry Oak and its Environment in Southwestern British Columbia, Canada

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There has been a great deal of interest in Garry oak (*Quercus garryana*) on southeastern Vancouver Island and the Gulf Islands, British Columbia (B.C.), Canada. Garry oak fascinates many people, largely because of its complex and visually appealing form. The sculptural, multi-stemmed form of Garry oak and the visual diversity associated with its environment are valued not only for wildlife habitat and ecological function, but for their ability to evoke a strong aesthetic response. As such, many cherish this tree and environment.

Garry oak is unique within B.C., its main distribution being to the south, extending to California. Garry oak ecosystems are among the rarest and most threatened in Canada, and are currently the focus of a great deal of conservation concern.

While highly valued by the citizenry, these landscapes are still being lost at an alarming rate to continuing urban development pressure in the Georgia Basin. Unfortunately the keen level of interest has not, as yet, translated into a more respectful approach towards the needs of this scarce and sensitive ecosystem.

This paper summarizes observations taken on the form of Garry oak, as part of an ecological survey. Specific topics of inquiry encompassed:

1) application of a Californian hardwood classification
2) biotic and ecological characteristics

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3) wildlife habitat features and classification
4) relationships between 1-3, including quantitative, correlation analysis.

Additional discussions explore the interactions and influence of other environmental factors and the aesthetic appeal of oak as related to form.

Most (about 65%) Garry oaks evaluated could be placed within the form classes of the California hardwood classification. It was necessary to add descriptors on an equal number. The relatively complex form class 3, and a corresponding form complexity value, were dominant across both years. In the year 1 data, parkland and woodland physiognomic types had large diameter oaks and high values for complexity index and wildlife-habitat features. Quantitative comparisons of form class and complexity did not yield definite statistical relationships with the other factors tested. The correlation results were less than the interpretive threshold in all cases.

Refinements to the hardwood classification system are suggested which depict curvy oak limbs, particularly large limbed trees with branches sweeping outward, as well as those which lean or have multiple stems. Further representing this diversity in trunk habit, number of stems and branching patterns should reflect higher levels of human preference or appeal. Modifying the classes would identify features in Garry oak which appear to be both ecologically and aesthetically significant.

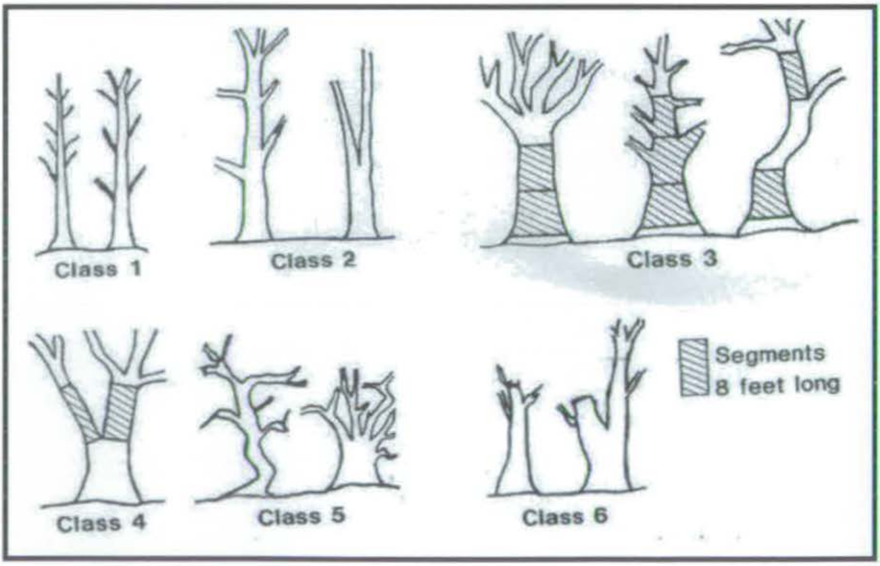

Figure 1. *Hardwood Form Classes (Bolsinger 1988)*

Since no strong ecological correlations were obtained, variables controlling oak form and complexity might interact, or they may not have been sampled and compared. Nevertheless, the higher values may suggest relationships between increasing diameter of oaks and higher form complexity, total wildlife habitat tree features, and increasing site moisture.

Introduction

Garry oak (*Quercus garryana*) ecosystems are currently the focus of a great deal of conservation concern, as they are among the rarest and most threatened in Canada (Erickson 2000; B.C. Ministry of Environment, Lands and Parks 1993). In British Columbia (B.C.), Garry oaks occur on the Gulf Islands and southeastern Vancouver Island, extending southward into California.

Garry oak is a Pacific coastal, deciduous white oak. In B.C. it varies in size, from prostrate 20 cm shrubs, to 30 m tall, 1.5 m diameter, widely spaced trees with full crowns. Most commonly these are oaks are between 12 and 24 m in height, and 25 to 75 cm in diameter. Garry oak has many branches and moderate-sized lobate leaves. It is considered a character tree. Like Arbutus (*Arbutus menziesii*), it has a "shaggy, twisted growth form", along with its gnarled aspect (Bodsworth 1970). Also, developing in response to severe environmental conditions are a couple of distinct shrub forms: one characteristic on the shallow soils of bedrock outcrops and the other on the exposed sea coast.

Form can be expressed at many levels, but in this paper form refers to the variation expressed in the physical shape of oak at the tree level. Form equates to appearance for the layperson, to internal coherence, in visual or aesthetic terms, and can be related to function ecologically. To the scientist form is physiognomy, and can be dealt with in a life-form classification. Garry oak seems to fit as a "persistent multilayer" in Horns (1971) simplified theory of the adaptations of tree form to environmental conditions. Multilayers have high drought resistance and are characteristic of dry climates. They are found in early successional stages, except on xeric sites, where they also occupy late stages. Other typical features include: a random distribution of small or lobed leaves within each layer; a low heat load per unit area of leaf; a high growth rate in the open; intolerance of shade; little shade production from their canopy; and lack of persistence through their life cycle under a canopy (op. cit.).

We undertook this research to add to ecological descriptions of Garry oak and its communities, and to examine the potential role of the combined factors of form, wildlife habitat features, and aesthetic appreciation in conservation significance, one of the societal values on which ecological concern is based.

Methods

Representative plots were sampled on a variety of sites across the range of Garry oak in B.C., in an ecological survey (Erickson, 1996, 2000). Tree form descriptions were integrated into the sampling to apply and test the California hardwood classification of Bolsinger (1988) on Garry oak. This six-class system (with 11 subclasses) (Figure 1) was developed for commercial properties of California hardwoods, in contrast to the ecological purposes of this study. Oaks were selected to represent the different size, layer and age classes, depending on stand physiognomy and heterogeneity. The sample consisted of approximately 650 trees, 250 plots and 100 sampling areas. From one to six oak trees were described on each plot, with tree number one being most typical. Testing consisted of a simple binary judgment applied to each sample tree. Addition or alternative descriptors were applied to augment or replace the Bolsinger classes.

Other relevant tree measures included diameter at breast height (dbh), estimated percent canopy cover, assignment into height-based (<0.5m; 0.5-2m; 2-10m; >10m) structural layers, and detailed wildlife habitat feature descriptions (Erickson 1996).

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Photo by Wayne Erickson

Garry Oak Canopy

Numeric scales were applied to allow quantitative examination of alphanumeric field data. Relationships were investigated via correlation coefficient of variation results for the environmental, biotic and the total wildlife habitat tree factors. Both the average and first tree values for form class and complexity were compared. Environmental factors included: moisture regime (an integrated estimator of site environmental factors); insolation index; depth of the A soil horizon; percent surface bedrock exposure; percent surface exposure of shallow humus over bedrock; soil depth to bedrock; and soil coarse fragments. The total wildlife habitat tree features were also analyzed. These consisted of dead main stems; dead limbs (small, medium, and large); scaling limbs; loose bark; tree crevices, cavities, and hollows; and perches. These data were collected within the context of developing a wildlife habitat classification (Erickson 1993). The biotic factors included average oak diameter; oak cover in the tree and tall shrub layer; and Douglas-fir (*Pseudotsuga menziesii*) cover in the tree layer. For the quantitative analysis, a threshold of: r-square= 0.15 (15% of variation accounted for); was used to interpret correlations.

Results

In the two-year results a total of 63.12% of Garry oaks could be placed in one of the Bolsinger classes. It was necessary to add descriptors on an equal number (63.5%) of the trees. Most frequently described was curviness of branches. Form class 3 was dominant across both years, with 40.4% of the total; followed by class 2 (28.6%); and class 5 (14.6%). The average numeric form class fell within the mid-range of class 3 (34.827, STD of 7.47). The numeric form complexity index gave a similar result (average of 36.11, STD 6.91). This generally held for each of the tree classes (class 1-6; range 32.1 to 38.4). The subclasses had a much more even numeric distribution, with 2b the highest (22.5%); followed by 3b (21.1%); 4 (19.9%); 3c (15.7%), etc. Of the trees not fitting the Bolsinger classes, the highest percentage (23.7%) were prostrate, or had extreme curviness (23.7%), followed closely (22%) by leaning oaks.

The form class data for Year 1 had a secondary dominant in class 2, and one physiognomic type with class 5. Several types (e.g. parklands, woodlands) had large diameter oaks, averaging 40 to 50 cm, and higher complexity-index values. These physiognomic types also had high scores for wildlife habitat features. Diameter was therefore taken as an index to the more complex form classes and to the wildlife habitat value of oaks.

Post-hoc comparisons of form class and complexity did not yield definite statistical relationships with the other factors tested, since the correlation results were less than the interpretive threshold in all cases.

Discussion

The moderately high fit of the sample trees to the Bolsinger classification suggests it may be useful for Garry oak in B.C. However, the high percentage of trees which required additional descriptors indicates refinements are needed. The necessity for changes is not surprising, considering the Bolsinger system was designed to identify potentially harvestable 8-foot segments of lumber. The nature of modifications is suggested by the frequency of the descriptors. Form class and complexity values confirm the prevalence of complex forms in the survey; and their selection as representative suggests this result should reflect the main condition in B.C. Adaptations to the hardwood classification system are suggested, in order to recognize ecologically or aesthetically significant features in Garry oak. Adaptations are suggested which depict curvy oak limbs, particularly large limbed trees with branches sweeping outward, as well as those which lean or have multiple stems. Interestingly, some of these features are already named and illustrated in a utilitarian context: the form of English oak suitable for shipbuilding timbers, which includes curving piece such as crutch, futtock, catshead, etc. (Miller and Lamb 1985).

The quantitative results were unexpected, and imply that the factors controlling form class and complexity may be difficult to determine. Key variables probably interact in complex ways. As no single test showed a result which could be interpreted as significant (threshold: r-square > 0.15); the variables might interact, or may not have been sampled (e.g. genetic factors) or compared. The highest correlation values (while still less than the threshold), were obtained for:

- the form complexity of tree number 1 (across all samples) compared with its diameter (13.3 % of variation accounted for-the larger the diameter, the higher the complexity).
- this same tree category for diameter compared with total wildlife habitat tree features (13.1% of variation- the larger the diameter, the higher the wildlife habitat feature values).
- and again, for diameter with moisture regime: 14.2% of variation, with increasing site moisture leading to larger diameters.

These quantitative comparisons should be viewed in a limited context, in that they are simple, univariate tests. If this is a multivariate question, with a number of variables contributing, this threshold may be set too high. Separations by plant community might refine the analysis. More sophisticated, and multivariate, methods might shed further light on the controlling factors of form class and complexity in Garry oak.

Several of the 1993 results focus on the need to represent the large diameter, large size oaks in the classification. These were the total scores, the total tree feature scores, the form complexity results, and also, from a wildlife habitat point of view (Erickson 1993), the average number of bird species per plot. There appeared to be a general relationship between the diameter of oaks in the different physiognomic types and the total tree habitat features. The average diameter of two physiognomic types (parklands, woodlands) was well above the accepted minimum for cavity excavation of 25 cm. (Backhouse 1993). These types also showed a tendency toward greater diversity of form and more bird species per plot. Large diameter corresponds to stately, open-grown, mature individuals, which have fully developed, complex form and correspondingly increased diversity

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of habitat niches. According to the habitat heterogeneity hypothesis (Strong et al. 1984), large oaks should support greater number of species, because they are older and have more surface area and volume for habitat features. Moreover, they would have more indicators of senescence, on which a number of the habitat features (and class 6 of the Bolsinger classification) are based. Nest cavities are the focus of the link with diameter in the U.S. literature: a significantly greater number of excavated cavities were found in Garry oak than expected in one study (Wilson et al. 1990), and substantially greater numbers of cavities than Douglas-fir in another (Gumtow-Farrior 1991). Rough furrowed bark is another characteristic of large oaks, which supports microhabitats for insects which, in turn, attract bark-gleaning birds. Large, old California black oaks (*Quercus kelloggii*) (Kerns 1980) and other western oaks (Verner 1983) provide habitat for birds in vertical edges, diverse foraging and feeding sites; produce more acorns; and furnish both resting and nest cavity excavation sites.

Form is significant in the adaptive geometry of trees, the way that tree shape (form) provides adaptations to the environment (Horn 1971). Hypothesized adaptations of Garry oak (Erickson 1997), relating to form and physiognomic type, include deciduous strategy:

- open canopy permits throughflow of wind, necessary for cross-pollination
- avoids drought, winter stresses including winter gales, and the damaging effects of disturbances such as browsing
- reduces autocompetition and allows the development of complex tree forms
- allows energy investment in below-ground biomass (high shoot to root ratios), permitting a long (e.g. 35 years) persistent seedling phase (Hibbs and Yoder 1993), release by fire or canopy gap, which, following a transition in form classes 1 and 2, contributes to longevity, windfirmness and the full expression of form

A number of ecological functions may be associated with the dominant full open-grown tree form of Bolsinger class 3:

- architecture allows efficient transport of moisture and nutrients, contributing to longevity in this dry Mediterranean climate (Kerr 1951)
- large canopy serves to intercept and funnel substantial rainfall to important root concentrations in both the base and outer canopy edges
- deep bark furrows serve as channels which speed this downward moisture transfer
- light penetration permits a rich spring flora to flourish, and affects many aspects of site ecology, such as pollination, predation, browsing, reduced establishment potential with early soil moisture depletion, long seedling phase, frequent fires with early growth cessation and flammability
- re-sprouting ability, thick furrowed bark, high bole and relative inflammability are among the characteristics in oak to cope with fire

- openness of form permits throughflow of wind, increasing wind-firmness and cultivating the development of rich arboreal lichen layers, with implications for site nutrition, but allowing rapid spread of wind-disseminated insects (e.g. Franklin 1973), offset by late but rapid leaf maturity and seasonally high tannin contents.

However, its important to bear in mind that trees do progress through the lower Bolsinger form classes (1 and 2) as they develop from seedling to sapling to small tree, and senesce via form class 6.

Reflecting on adaptive geometry allows environmental and historical interpretations. On deep soils and favourable sites, woodland physiognomic types are narrow-crowned and partly clonal, indicating growth in a competitive forest stand. Oaks ability to resprout can determine form in multiple-stemmed and thicketed oaks. This results when more severe fires top-kill oaks and stimulate surface roots, leading to a dense stand. Open savannah settings within the parkland type had an open-crowned form indicating past open, savanna-like conditions. These stands experienced frequent light understory fires, and the remainder of the parklands had a mixed regime. Environmental severity is the main determinor of the two remaining physiognomic types; moisture and nutrient limitations in the case of the shrub oak-rock outcrop type, and the damaging effects of wind and salt in the case of the krummholz sea-edge physiognomic type. In this latter case, oaks start as a 20-cm mat and grade upward to about 2 m in height with distance away from the exposure.

However, a number of factors have changed the natural interactions in form of Garry oak. Widespread encroachment of Douglas-fir (Erickson 1996), resulting from fire suppression has left the slower-growing oak overtopped, forcing tall spindly forms (Bolsinger class 1, 2) and causing mortality after canopy loss. Canopy damage, branch mortality and death are also being caused by introduced pests including winter moths, jumping gall wasps, oak-leaf phylloxeran. Garry oak may decline under the cumulative stress of drought, insects, disease and human impacts (e.g. Clinton and Boring 1993). Throughflow of wind, a clear adaptation of this oak, is locally being disrupted by invasions of ivy (*Hedera helix*), which covers the Garry oak stem and branches with a dense, heavy, evergreen canopy, risking vulnerability to toppling in heavy winter gales.

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Mature specimens of Quercus garryana *display their sculptural form in British Columbia.*

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It is suggested that a relationship may exist between the level of aesthetic appeal of Garry oak and its placement in the Bolsinger classification. If so, the Bolsinger classification may provide a means for predicting the relative level of preference for a given landscape.

In general, higher Bolsinger classes encompass tree forms that are much more diverse in terms of trunk habit, number of stems and branching patterns. Such stems are visually rich and diverse and may, in reflection of the discussion above, result in higher levels of preference (or appeal) than stems ranked lower on the Bolsinger scale.

Research suggests that the most preferred landscape types include savannah and oak woodlands (Balling and Falk 1982, Appelton 1984), landscapes with mystery and complexity (Kaplan 1984, 1987) and/or a variety of interesting vegetation types expressed in attractive forms, textures, patterns and shapes (Hamilton 1995). The landscapes characteristic of Garry oak in general, and its form specifically, conform to these qualities, providing some initial insight into the almost-universal appeal of this tree. Accepting the notions suggested by landscape preference research infers that individuals will have a greater preference for oaks with forms characteristic of Bolsinger class 3 or greater.

Conclusions

The form survey results both confirm the utility of, and suggest adaptations to, the Bolsinger system for the purpose of describing Garry oak in the B.C. range. Adaptations are suggested which depict curvy oak limbs, particularly large limbed trees with branches sweeping outward, as well as those which lean or have multiple stems. Some descriptive terminology is available from historic categories of shipbuilding timbers. Further representing this diversity in trunk habit, number of stems and branching patterns should reflect higher levels of human preference or appeal. Modifying the classes would identify features in Garry oak which appear to be both ecologically and aesthetically significant.

The quantitative results in this study suggest that the ecological effects, which both control and are associated with the form of Garry oak, probably interact in complex ways. Since no strong correlations were obtained, these controlling variables may also not have been sampled and compared. Nevertheless, the highest values calculated may suggest relationships between increasing diameter of oaks and higher form complexity, total wildlife habitat tree features, and increasing site moisture.

Garry oak seems to be supremely well adapted to its environment, as suggested in this discussion of the relationship between its form and ecological function, a rich subject for qualitative interpretations. The depictions in the historical accounts illustrate that the aesthetic value of Garry oak and its environment hold a special appeal and fascination for many. The manner in which the tree and its environment are employed in the urban landscape suggests that the tree and its environment have, over time, assumed a deeper, symbolic meaning.

Studies of landscape preference indicate that the almost-universal appeal of this tree could be the result of several factors. Because these refinements will serve both ecological and aesthetic purposes, it may be that they will assist in preserving this tree and its environment, as preservation action is the logical link between aesthetic awareness and ecological concern. Further understanding of ecological adaptations relating to the form and function of Garry oak and its associated plant communities can only help in these efforts by increasing the public's appreciation, interest and tolerance.

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