AN EXAMINATION OF STRATEGIES FOR BIOLOGICAL CONTROL OF SCOTCH BROOM CYTISUS [SAROTHAMNUS] SCOPARIUS (L) LINK

by

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Term Paper

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ABSTRACT

Biological control of weeds is examined using strategies employed to control Scotch Broom, Cytisus scoparius. A model is suggested giving a basic framework for a successful program. Literature on biological control of Scotch Broom is reviewed and compared with the ideal as a test case. The introduction of a Lepidopteran stem and leaf minor, Leucoptera spartifoliella by two workers and the use of Apion fuscirostre by another worker is discussed. It is concluded that the necessity for biological control of Scotch Broom is not supported by the evidence, and in fact, many basic requirements for conducting a successful program have been ignored or are not reported. In particular, the pre-examination stages, fully classifying the plant as a weed and the subsequent choice of a stem and twig minor appear to be incomplete. The difficulty in obtaining continuity of staff and funding is recognized but is suggested as essential for successful results. The rapid pace of development in other control methods is noted as a major deterrent to embarking on biological control of weeds with anything other than a fully financed, mission oriented, team who have established clear project goals. It is suggested that to dilute any of the documented procedures for biological control is to court failure and discredit the benefits of the technique. It is noted that the ~~owners~~ onus for effective scientific conduct rests not only with the end user but also with the applied researcher.

INTRODUCTION

Carl Huffaker writing in the National Academy of Sciences Revue Of Week Control (1) states that "there is often unwarranted criticism of biological weed control which may affect decisions to undertake such programs. One view is that since the method demands no effort from the agriculturist, it promotes neglect of proper management." The purpose of this paper is to test the validity of this contention using as an example a "weed" chosen at random and known to have been the subject of biological control attempts as outlined by Holloway in De Bach (2).

In order to examine the success or failure of the strategies used for biological control of Scotch Broom, a brief framework is suggested here, outlining the basic component for a theoretically ideal biological weed control program. The literature has been searched to determine the actual importance of Scotch Broom, and understanding

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of the plants background and the status of its control and management. This is presented in the format outlined as necessary for a sound biological program. Conclusions are drawn after the comparable match between the ideal and the actual in the context of ~~half acres~~ contention that there is often unwarranted criticism of such programs.

BIOLOGICAL CONTROL OF WEEDS - THE IDEAL CASE

Huffaker writing in ~~the Bar~~ (2) introduces a chapter on the Fundamentals Of Biological Weed Control with the classical definition of a weed as a plant in the wrong place and continues "weeds may be related to, or themselves may be, valuable plants in other situations. This fact is fundamental to consideration of biological control. For this reason each weed subject must be considered from many points of view." It would seem then, that a basic rule must be the assessment of a plant in a complete context and a thorough comparison of benefits versus detriments conducted. This writer would suggest that economic considerations alone are not sufficient but should be suplemented by ecological and aesthetic studies. The plant must clearly be a pest to warrant control.

Since ~~irradication~~ is not a reasonable (nor desirable) expectations of biological control Huffaker (3) the weed must have an impact which requires only partial reduction in occurrence or density to satisfy the land use managers requirement and rationale for control. Further safety must be a prime concern in the biological control of weeds. Williams (4) strongly stated this position in 1954 "the critical phase of biological control work against weeds is the selection of species that will not harm other plants, or at least useful plants. All other considerations are subordinate, and a suitable species for introduction into a country against a weed is one that is safe to introduce, ~~the~~ respective of its other characteristics. As a first then and in recognition of this requirement and the implied penalties of time and cost of development it would seem reasonable to have exhausted other means of control, mechanical, chemical and cultural, before indulging in a n extensive biological control program. This would insure that scarce resources of funds and talent are directed only to priority programs.

If these initial criteria are satisfied it is possible to progress to the stage of reviewing specific information. This author would suggest that a problem presented by a suggested weed, in this case Scotch Broom, requires an extensive literature review in a number of "bodies of knowledge" some ~~some~~ scientific some not. Botany and Taxonomy, Plant Physiology, Entomology, Pathology, Ecology, Agriculture, Forestry, Horticulture, Gardening both modern and historical, early Herbals, literature of other control measures and knowledge of specific land users, right-of-way managers for example, may all contribute important prospective and information on the status of a plant and its suitability for control.

Detailed information is required from the above sources on two ~~currents~~ counts; Weed data and Control agent data.

Weed Data

1. Taxanomic position
2. Biology
3. Ecological requirements and importance
4. Examination of economic importance, classification as a weed other uses, rationale for control.
5. Native distribution and probable center of origin
6. Present distribution and severity of infestation
7. Co-extensive occurrence of related species
8. Occurrence of related or ecologically similar species where weed does not presently occur.
9. Degree of control required
10. Literature assessment of known natural enemies

It appears generally accepted (3)(4)(6)(7)(8) that alien perennial weeds introduced free of their native enemies are the best prospects for biological control and that introduction of new agents provides the greatest probability for success although detail host specificity work by Wilson (9) may well weaken this long herald tenant.

Other important indicators which may at this stage serve to underwrite the probability of success are:

1. That the weed is not classed as such trough failure to recognize basic cultural or edaphic requirements or through mismanagement, as in rangeland overgrazing.
2. That the weed does not show any inherent resistance to possible control agents.
3. That environmental factors do not markedly favor the weed over a possible control candidate.
4. That there is no obvious discontinuity between the environmental range of the weed and the probable range of the control organism.
5. That techniques, risks, costs, and logistics of introduction are all determinable factors of that some of the actual information will only be generated by undertaking the project.

Once the questions raised above have been satisfied the review of the candidates both pathological and entomological, if they exist, may begin. Few programs using diseases appear to have been attempted. Muzik (10) rather fasciciously points to

Chestnut blight and Dutch elm disease as two prime examples of accidental, highly disastrous, but in biological terms successful introductions. More interest seems to have been given to secondary infestation after insect attacks as in the case of bacterial rot after Cactoblastis infestion of prickly pear (11).

Insects constitute by far the largest group of natural enemies of weed weedy plants (5) and historically appear to be the group of phytophages most studied. An ability to predict with any accuracy the effectiveness of any entomophagous insect still seems to frustate the entomologist. Perhaps as a consequence multiple introductions have been favored by some (1) with the added support that the introduction of a complex of enemies has not been recorded as detrimental.

The qualities an insect should possess if it is to be an effective agent in controlling a weed are suggested here after Huffaker and Muzik as:

1. Host specificity to the extent of starvation if the host is not available.

2. Ability to kill the plant or prevent reproduction.

3. High ability to disperse successfully an effective host searching.

4. Freedom from own predators, parasites and resistence to those found in the new area.

5. Good adaption to weed host and environmental conditions over maximum part of the weed range.

6. Reproductive capacity sufficient to overtake increases in host plant if numbers reduced by climatic conditions.

With these criteria to guide, an assessment can now be made of candidate agents in real terms. Huffaker suggests that an exploration area should be mapped with similar climate, where the host plant is native, near the center of origin and in an area with a variety of ecological conditions. Exploration should comprise some four phases.

1. General Inventory	(a) Field (b) Literature (c) Museum Records (d) Local knowledge
2. Sampling for Quantative Data	(a) Weed density (b) Pest effectiveness and population dynamics (c) Influence of environment and season
3 Concentrated Study of Single Agent	(a) Life history (b) Distribution (c) Importance (d) Specificty (e) Parasites, predators and patogens

4. Examination of Complexes

Once encouraging results are obtained, laboratory testing can be considered. Procedures for feeding, breeding, host specificty, preference, etc., are well documented but most obviously satisfy scientific, economic and legal criteria. Once accomplished, introduction becomes the next step, to be followed by the logistics of release and finally evaluation of results. Huffaker succintly states (1) that "the ecologists must be prepared to carry out painstaking studies over a period of years if he is to document his case". The degree of pest reduction, replacement ecology, success in the establishment of the bioligical agent and an appraisal of cost/benefit appear important considerations here. Detailed records before and after introduction are obviously mandatory.

After careful step-by-step progression through the components outlined in this section there would appear to be a fair chance, but no guarantee, that the program manager will be rewarded with "success" in obtaining biological control of a problem weed. Just how complete and effective one particular project has been is detailed in the next section which examines the case of Scotch Broom.

BIOLOGICAL CONTROL OF WEEDS - THE CASE OF SCOTCH BROOM

Willard Arnold-Foster writing Country Life (12) noted that Broom makes as bright a show as any shrub which grows, and Genders (13) notes that it is the most valuable garden shrub for dry sandy soil. It is a plant of considerable horticultural merit. It has historical significance as the badge of English plantagenet King Henry II (14) strangely as a sprig in pod not in flower. Alice Coats in her thorough and delightful Garden Shrubs and their History (15) recounts the Brooms soporific and magical powers quoting the well-known Scottish ballad of The Broomfield Hill. Turner (16) in his early herbal suggested medicinal properties to cure sciatica and as late as 1945 Broom tops were collected to extract a drug used for liver and kidney complaints (14). These are but a few illustrations of the diversity of use for Broom which are further expanded in the detailed review of the plant.

While the literature both historic and taxonomic is comprehensive, published information confirming the status of Broom as a weed is scant indeed. In a careful review of the literature back to the late forties, barely half a dozen references are available, and indeed the three papers (17) (18) (19) primarily concerned with reporting the biological control of Broom in the United States devote ~~on this known~~ almost space to classifying the plant as a weed. The principal paper by Frick (18) in fact refers only to work by Ball and Kochler in California who indicated in a broad review (20) that Broom was a serious weed of range and forest lands occupying about 100,000 acres. This seems a relatively small acreage in this writer's judgment. The work by Andres (21) on the use of a seed pod weevil Apion fuscirostre is also lacking in detailed assessment of Broom as a weed. Waloff (22) in a review of the fauna of Scotch Broom notes that Frick and Parker (17) indicate that Broom is a weed of sufficient importance to warrant the introduction of its insect enemies. Parker's paper, in fact, is a review of the life history and testing of the stem and twig minor Leucoptera spartifoliella on Broom but that makes no mention whatever that the plant is a weed warranting such attention. Waloff also cites Holloway in De Bach as noted before. This reference again provides no detail assessment of Broom as a weed but merely indites it as "a pest on range lands and hindering reforestation

by competing with seedlings, it also increases fire hazards among older trees." This latter point is interesting in the light of comments by Coats and Pizzetta (23) where it is noted that European gypsies to sweep out their brick ovens after the fire is spent but before they put in the bread since Cytisus does not catch fire easily.

Simmonds (24) in his detailed review of Biological Control of Pests of Veterinary Importance, section I Poisonous Species, lists Broom but strangely notes that it is in fact non-toxic. The principal grievance seems to be that it is of little or no value as feed (though as to what animals this applies there is no mention) and that it crowds out more nutritious and hence economically valuable grasses. This is quite contrary to other writers as early as Aubrey (25) and as recent as Pizzetta who notes that it has provided valuable winter fodder for sheep and may be useful as ~~foliage~~ and is said to increase cows milk yield. Of the ~~nature~~ weed textbooks, Gilkey in Weeds of the Pacific North West (26) makes no mention of Scotch Broom nor does King (27) in Weeds of the World. There are, however, some ten published papers from New Zealand reviewing work to control Broom with herbicides where it appears to be a minor problem on ~~rare~~ rights-of-way and reforested land. Muenscher in the text, Weeds (28) does mention Broom briefly ~~that~~ but gives no indication of its status as a weed.

If it is agreed that biological control is a last resort as a means of control chiefly for alien weeds introduced without their natural enemies (already brought into question in the case of Broom by Smith (29) who 20 years earlier had ~~formed~~ found Leucoptera on Broom in Washington presumably in peaceful ~~symphony~~ with the plant, much no doubt to the surprise of Frick and Parker who had spent 1968 and 1969 doing careful host acceptance tests and finally receiving U.S.D.A. permission in 1961 to import cocoons from France, the ~~combination~~ of work begun in 1951) it would seem reasonable to have examine other methods of control and found them wanting. Unfortunately, the ~~office~~ of the known papers on biological control give no information on their assessment of other such methods.

It is at this point that the reviewer becomes increasingly conscious about the rationale for, and the scope of, research undertaken by workers in biological control of ~~these~~ weeds. Since information in the literature strongly suggests that both mechanical and chemical controls are available, effective and relatively inexpensive. Writers of the calibre of Osborn (30), Hellyer (31) and Genders all cautioned that garden pruning must be extremely light and that cutting back into two year old ~~root~~ will almost always cause dieback since Cytisius scoparius rarely breaks new shoots. Further, Patterson (30) reports complete control with the herbicide Picloram after nine months. Moffat (33) found Picloram and ~~too~~, 4-D effective and economical as did Stevens (34). Vietz (35) erradicated Broom from a derelict area with two treatments with 2 4-D while Zanardi (36) Preest (37) Pangelly (38) ~~Newsome~~ (39) Arbonnier (40)(41) had similar experiences in forestry and ~~posture~~ situations. Kennedy (42) reports good control with Diuron and Simazine in a tank mix on railways in New Zealand while a recent (1970) Oregon State Publication by Warren (43) indicates good control of tall Broom (1 to 2 meters) with Picloram and 2,4, 5 -T. Jaarb (44) writing in another context; weed control in potted nursery Brooms, notes that Prefix (Chlorthiamid) caused cork-like thickening of the root, causing the plants to snap off at the base. This undesirable trait in the nursery might perhaps hold potential for control in the range ~~of~~ forest setting especially as Prefix is already used to some extent in forestry.

Only passing reference is made by the three principal workers in biological control of Broom to the type of information suggested in the previous outline of data required on a potential weed. It should not however be construed that this information is lacking as is shown briefly in the following summary.

Taxonomically, Scotch Broom is a legume of the Pulse family. Coats notes that Cytisus, Genista and Spartium are all families which have enjoyed much discussion amongts the botanists frequently being transferred from one genus to another. Originally Laburnum was also considered to belong to the Brooms. Scotch Broom has made checkered progress from Spartium by Loudon (45) through Cytisus as described by Gray (46) and Hitchcock (47) (the separation of Cytisus from Genista is distinguished by a small strophiole on the seed of cytisus) to Sarothamnus suggested by Koch and adopted by Wimmer and later Clapham (48). It cannot be said then, to have a clear cut and separate taxonomy from a number of other plants. Moreover Sherk in Ornamental Shrubs of Canada (49) lists 12 horticultural derivatives of Scotch Brooms while Taylor (50) lists no less than 20 varieties ranging in colour and stature. Much of the breeding work appears to have originated at the Donard and Smith nurseries in the United Kingdom between 1900 and 1935 (51) although its original introduction into the United Kingdom is recorded by Miller (54) as 1629 when it was called Cytisus fecundus.

The origin of Broom and its latin name is somewhat obscure but Taylor (52) indicates its origin as western Asia and the Mediterranean. Coats in a more thorough examination quotes Maund (53) are suggesting that Cytisus is indirectly derived from Cythnus (now Thermia) an island in the Greek archipeligo where the ancients called it Kytisos. Pizzette indicates that the specific name, scoparius is of latin origin meaning broom. The use of Scotch in the common name is not explained anywhere in the available literature but presumably can be attributed to its wide use for fuel and forage in the poor ground as described in the origin Statistical Account of Scotland in the 1700's (55). The plant widespread use for making brooms must account for its obvious adoption in the common vocabulary. Broom must certainly have been widespread in range during the Middle Ages since many place names are based upon it but no reason for its demise is obvious. Improved agricultural practice would seem to be the most likely reason. Range in North America is definitely limited by climate according to Taylor, and Coats records seeds ~~to be~~ sent to Pennsylvania in 18th Century but the plants perished in the hard winters. Zone 3 appears to be the hardinest limit for Cytisus scoparius. Dietz (56) indicates that it became naturalized in the south of the United States partly through the effort of Thomas Jefferson while Giechey (57) suggests that introduction at least to the Pacific Coast was early settlers as an ornamental. This being the case it seems unlikely to have come without a representative complement of native ~~foreigner~~. Lindroth (58) and Scudder, however, favor the suggestion and partial evidence that the plant was introduced along with ballast dumped from sailing ships arriving from the United Kingdom. That it is naturalized on the Atlantic and Pacific Coast of North America and has been for some considerable time, this certainly without doubt. Waloff in his very complete study of the insect fauna of Scotch Broom unfortunately undertaking after the attempts of Frick and Parker also gives ~~the~~ a complete review of the present range of Broom.

The cost/benefit of attempting biological control of the plant in its undesirable role of invader of range and forest land has to be weighed against on the one hand its many uses and on the other and its apparent classification as a weed. Arriving at a value for the horticultural uses alone is difficult. For Canada, ~~this~~ one takes an average nursery value of $4.00 per plant (60) and some 25,000 plants per annum (a rough estimate based on Dominion Bureau of Statistics figures (61)). The annual nursery value alone is $100,000.00. In addition the plant has a major use as a soil stabilizer on highway projects, Huffaker (1) and Waloff. Without undertaking a comprehensive study it is possible to suggest that a horticultural value of Scotch Broom is very considerable, a point unfortunately ignored in the ~~public~~ published literature of workers on biological control of the plant. Certainly it is a plant with a myriad of uses. Coats, Gregson, Pizzette, Parker and Kloss (62) Culpeper (63) and Gerard (64) variously report its use for: brooms, ~~fatching~~ thatching cloth and papermaking, tanning, dyeing, cabinet work as a veneer, making potash, fuel, fodder for sheep and cows, salads, scent, a diuretic, purgative, emetic cathartic and perhaps of interest today, the seeds apparently make a good substitute for coffee. Scotch Broom certainly has some ready uses in its favor to counter its apparent disfavor in range and forest land, its aesthetic qualities apart.

Botanically as noted before it is a member of the Leguminosae, a tall growing shrub, 1 to 2 meters in the common form with bright yellow flowers borne in May on fine, five-angled twigs. Leaves are distinctly petioled, leaflets trifoliate narrowly elleptic to obovate acute, and with appressed pubescence. It is normally an evergreen perennial preferring well drained sandy soils and is strongly calcifuge. Cloud (65) notes that it is very shade intolerant a factor which presumably could be used to good advantage for sivicultural control on forest lands. The plants natural ecological niche acute appears to be poor uncultivated land; rocky dry knolls, steep well drained banks, waste and derelict ground, roadside and fire breaks. It is dispersed by explosive dehiscence from pods which mature in July. Pollination is primarily by bees. The plant is mature in 8 to 10 years after which it becomes overgrown, susceptible to wind damage and deteriorates rapidly.

There are a number of related Brooms: C. monspessulanus L., French Broom, C. racemosus, and Spanish Broom Sparticum junceum L. as well as many species of Genista which occur throughout a similar range of Scotch Broom. However, the work by Parker and Andres seems to rule out the possibility of attack on these and ~~ever~~ related species. However, with regards to the ~~finer~~ points in my section outlining the data needed on a potential weed prior to biological control attempts, the need for a complete review of the ~~plans phytophajos~~ insects, it does not seem that this was undertaken until 1963 by Waloff, some 3 years after the introduction of insects from France. Indeed, it would seem that a chance remark by a Director of a French agricultural station that an attempt to grow Scotch Broom for paper in southern France had failed because of attacks by L. spartifoliella was all that initiated the original work with this insect (Parker).

Although the requirement for determining a suitable control agent appear to have been largely met from this stage, although I can find no reference to the insects dispersal ability, work was restricted to one insect alone until the more recent work on the seed pod ~~weavel~~ by Andres. This unfortunate, particularly since all

that could be expected from a stem and twig minor was a reduction in growth and vigor. Pirone (66) in Diseases and Pests of ornamental plants notes a Leaf Spot, Bright, Ceratophorum setorum which apparently kills the plants in two weeks while Westcott (67) lists six cankers, nematode, and an agressive root rot as important pests of Scotch Broom. A broader spectrum of review would perhaps have served to provide a more suitable agent. In fact, it appears that even the entomological field might have yielded a wider of range of possibilities. Waloff records some 35 phytophagous species on Scotch Broom in his work published in 1966..

CONCLUSIONS

A number of obvious and subtle conclusions can be drawn from the facts recounted here. A plant must clearly be a weed on a large scale to justify the time, effort, risks and expense of a biological weed control program. Simple cost-benefit and risk-benefit studies would appear to have a place in this type of assessment. Somewhere priorities must be set. It would seem that a project of this kind is ideal for mission oriented applied research with an inter-disciplinary team if it is determined that a particular plant is indeed a major problem. Other control alternatives, at least if they are effective and efficient, should be exhausted first. Moreover, the time involved in conducting the prerequisites of a biological control program must take account of the rapid development of other techniques. The development of herbicides in the 15 years of this program, for example, have been staggering. Thus setting clear and concise objectives, degrees of control hoped for, and time targets should be an early task of any project team.

Very thorough review of the literature from all facets and careful field studies of existing fauna of potential weeds are an obvious need before a project can be seriously embark ~~upon~~ ed upon.

Sadly, no records in the literature could be found which reviewed any long term results which had accrued from the 10 years of research. In fact, the brief observations by Frick at the time of the research which amongst other advantages claim the 50% reduction in seed pod production in some plots, omitted to record whether these might have been damaged from the seed pod ~~weavel~~ weevil later found by Waloff, and failed to examine the viability of the seed which was compared from plots in quite different areas. Perhaps continuity of staff and funding was not possible. Certainly Frick, when he wrote his paper was by then located in Rome. This, however, reinforces the need for long term assessment of results, continuity, and eventual publication.

The conclusions drawn here are not necessarily those enhanced by hindsight, they are observations on the necessity to be complete, to examine as broad a spectrum of facts as possible. To do otherwise is to waste valuable time and effort and discredit the aims and successes of biological control. Perhaps it is not the agriculturist alone who must be careful that biological control may "promote neglect of proper management" for it seems that the biologist as well is not above some suspicion.

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ABSTRACT

Howe Sound is unique in the world. Only minutes from Vancouver by road or water, the scund offers a peaceful counterpoint to the busy city. It provides excellent recreational fishirg, boating, hiking, nature interpretation and motor touring. Such recreation can continue along with resource extraction and industry if care is taken to avoid unnecessary conflict among those using Howe Sound.

The future of the sound is not yet determined. Present heavy industrial and mining proposals could damage the physical environment and the recreational value of the sound if care is not taken to respect the character of the area. Yet the importance of the sound for recreation need not, and indeed should not, completly exclude other development optiens.

The purpose of this study is to present guiding principles to support future development, to illustrate the impact of such principles in a scenario format, and to propose an administrative system for implementing the guiding principles. Preparation of this study has been the responsibility of students registered in the Natural Resources Management Seminar (602) at Simon Fraser University in the Fall Semester, 1982. The report is intended to initiate further detailed discussion on the future of the sound and to help the public, industry, resource extractors and recreationalists examine their needs and aspirations for the future development of Howe Sound.

THE CHARACTER OF HOWE SOUND

Howe Sound is the southern most inlet on the mainland coast of British Columbia, north of the Strait of Georgia. Adjacent to the lower mainland, it is located between two major recreation areas, Whistler to the north and the Sunshine Coast to the west. The Howe Sound area encompasses a 7-km radius of land around the sound including Gambier, Bowen, Anvil, Keats, Bowyer and Pasley Islands.

The sound has a diverse resource base, particularly with respect to the land-water interface, and current uses are closely linked to this base. These include forestry and related activities, mining, fishing, recreation, wildlife, residential, and industrial uses.

The waters of the sound have long been used for the transport, sorting, booming, and storage of logs. The upland areas surrounding the sound are an important source of timber for the region's forest products industry.

Metal mining, particularly copper, and the extraction of aggregates, occur in isolated areas of the sound. The major mineral deposits are located at Britannia, Gambier Island and Stawamus River-Mount Baldwin area. Aggregate deposits are found at Port Mellon-Hillside and McNab Creek.

The waters of the sound support large sport and commercial fisheries. Numerous creeks which drain into the sound and the

associated estuaries are important habitat areas for the fishery resource.

The waters of the sound, its islands and stretches of shoreline are used extensively for recreation, particularly by people from Greater Vancouver. In addition, the scund provides scenic and viewing opportunities with its high mountains and steep topography. These characteristics offer diverse recreational opportunities and activities such as boating, fishing, hiking, camping, cycling, scenic driving and picnicing. There are a number of recreational facilities in the sound including marinas, yacht clubs and public wharves. Provincial parks are located at Plumper Cove, Apodaca, Murrin and Porteau Cove and in addition there are three proposed parks: Halkett Bay, Deeks Lake and one on Bowen Island. Other facilities include the Royal Hudson train, the BC Museum of Mining at Britannia and the ferry rides to the islands and across the scund to the Sunshine Coast.

The diverse environment of the sound includes mountain peaks, forested slopes, flat bottom lands, streams, estuaries, bays, islands and water. It provides numerous habitats capable of supporting a variety of wildlife including mountain goats, deer, small furbearers, waterfowl, shorebirds and marine mammals.

The major industrial uses of Howe Sound are kraft pulp and paper mills at Woodfibre and Port Mellon and chemical plants at Squamish. Water-borne transport is another industrial related

activity and includes log booming and storage and the busy ferry traffic at the mouth of the sound.

Thus, Howe Sound supports a multiplicity of uses. The proximity of the sound to the large population and industrial complexes of the Lower Mainland serves to intensify these uses. Competition for various land and water areas and their related resources is high. Yet each of these is important to the region's economy or to recreational pursuits. No one major use can take precedence without heavy costs to others.

DEVELOPMENT TRENDS

Current proposals for development in Howe Sound can be characterized as incremental and conflicting. In particular, present and future demands for recreation areas and foreshore access conflict with proposed industrial and housing developments. Industrial developments under consideration include an open pit copper mine on Gambier Island, aggregate mines on either side of the sound, and the rehabilitation of mineworks located above Britannia Beach. In addition, there are plans for the development of more dry land log sorting areas, a lumber mill and an industrial park for the area between Langdale and Port Mellon on the west side of the sound. There is also an industrial park being developed at Squamish. These industrial parks are being studied as alternate sites for industries no longer considered appropriate for location in Vancouver harbour.

On the basis of both permanent alienation of land and potential environmental degradation, such proposed industrial developments would result in conflicts with housing and recreational uses of the sound.

Housing developments, if allowed to proceed in an uncontrolled manner, can also negatively affect recreational values in the sound. Such uses may alienate prime recreational public access lands and degrade scenic vistas.

Recreational use of the sound, which is already extensive, is also expected to increase. In addition, Howe Sound continues to be affected by external forces. In particular, consideration must be given to the desirability of the continued use of the sound as a highway transportation corridor for the rapidly developing Whistler Pemberton area.

EMPHASIS FOR THE FUTURE

Given the current system of land and resource development in the sound, where there is a mix of uses which are proposed and approved essentially in isolation from other use proposals, conflicts are inevitable. Such conflicts could be minimized by planning for exclusive uses of the area. For example, the sound could be managed so that industrial development is encouraged or, at the other extreme, the sound could be reserved exclusively for recreation and preservation purposes. However, given present

uses and trends in the sound, these extreme options are considered unrealistic. If an exclusive use of the sound were identified, political pressure for allowing competing uses would build up to the point where piecemeal exceptions might be made.

While the implementation of a planning process for the sound which recognizes mixed resource development is recommended, an emphasis on recreational use is also suggested. Recreation is emphasized as a priority use for two reasons. First, Howe sound, due to its close proximity to a major population centre, provides excellent opportunities for a diverse range of recreational activities. Second, recreation is fundamentally different from industrial uses in that recreation involves little physical change to the environment or land base thus preserving all development options for future generations.

In the past recreation resources such as Stanley Park have been preserved more as a result of good fortune than good planning. However, given current trends in the development of Howe Sound, it is unreasonable to assume that uncoordinated changes would result in a desirable mix of recreation and industrial opportunities. Therefore, management actions will be necessary.

MANAGEMENT PRINCIPLES FOR HOWE SOUND

The intent of these suggested principles is to provide guidance for the evaluation of proposals for Howe Sound so that a controlled mix of uses with an emphasis on recreational use is achieved.

1. Management is to be conducted in such a way as to minimize option foreclosures.

   Certain types of development have consequences that are practically irreversible, thereby reducing the range of future alternative uses. Options with this characteristic should be avoided where possible so that the ability of the sound to be adapted to changing social values is preserved.

2. Secondary and tertiary effects of management actions are to be considered.

   Occasionally, management programs or plans produce negative side effects that were foreseeable but were not planned for. Proposals for the sound must provide an analysis of their effects beyond the initial objective and a plan for mitigating those that are negative.

3. When evaluating projects, distributed benefits are preferred to concentrated benefits.

   For projects of equal net value, the one that produces some benefit for many people is preferrable to those which produces much benefit for few people.

4. Management will be based on environmentally sound criteria recognizing that there are biological and other thresholds which must not be exceeded.

   This principle recognises that the sound has unique, finite absorption capacities for the effects or outputs of certain uses. These receiving environment limits, rather than general standards that may not apply, are to be used to determine permissible emmission and activity levels.

5. The primary future use of Howe Sound will be recreation for non residents.

   This statement recognizes the value of the sound as a

recreation area for the people of British Columbia.

6. Other future uses must not conflict with recreation or recreation potential.

   Uses other than recreation will be permitted to develop provided that they are compatible with existing recreation and do not foreclose future recreation options. This statement recognizes that the sound is to be managed as a multiple use area.

7. Management is to be conducted in such a way as to provide a diversity of recreational opportunities.

   The multiple use concept is to be used within uses as well as between uses. The sound will be used in an attempt to meet the range of recreation demands presented by society.

8. There will be some sustained yield of renewable resources permitted in Howe Sound.

   Consumption of renewable resources will be permitted to occur at some socially desired level that will not necessarily be the maximum sustainable harvest level.

9. Howe Sound will be used as a destination recreation area and not a transportation corridor.

   This principle recognizes the inherent incompatibility of recreation with efficient transportation. Alternative transportation routes should be developed to minimize the conflict between those who wish to maximize their exposure to the recreation opportunities in the sound and those who wish to minimize their transit times.

10. Existing uses of the sound must move toward meeting these principles.

    Existing uses that conflict with a recreation emphasis will not be removed from the sound, but will be expected to comply with these principles.

11. The effects of external influences on Howe Sound are to be managed with respect to these principles.

    Projects that originate outside the sound and that impact it are to be managed so as to ensure that the impacts within the sound comply with these principles.

SCENARIO

If future development were to be based upon these principles, then the following is our vision of Howe Sound in the future.

A visit to Howe Sound in 2001:

Good planning in the early 1980's made Vancouver one of the few cities in the world today with excellent recreational opportunities within easy, inexpensive access to all. For tourists, the Royal Hudson is a popular day trip to one of three possible destinations: to Britannia Beach to visit the mining museum, to Shannon Falls or to Squamish to visit the Nature Park and industrial interpretation centre. Many hikers, climbers, boaters, and divers use the trains to gain access to the excellent resources in the area. Challenging, well-constructed trails lead to the mountains around the sound and, for the more intrepid, there is the Howe Sound Crest Trail, a journey of several days from Cypress Bowl to the Stawamus Chief. The Chief and Murrin Park continue to be popular destinations for climbers because of with improved camping facilities at both sites. For those seeking to enjoy the beaches many new camp sites have been created at popular vantage points. Two more marine parks similar to that at Porteau Cove have been established to meet the needs

of divers. In winter the railway provides efficient access to Whistler.

Highway 99 is one of the most beautiful scenic highways in the world and in spite of increasing fuel costs many people still travel by car along the sound. In the past the road did not cater adequately to the needs of the recreational driver. Speeding through traffic, logging trucks and heavy transport made the journey hazardous. Now most of the through traffic travels via the new highway from Indian Arm to Squamish and the Howe Sound route is largely the domain of the recreationists. Large frequent pullout areas have been established and speed limits have been reduced to encourage more leisurely driving. With less dangerous traffic it has been feasible to establish a cycling route.

Two dramatic changes that have been made in the sound over the last twenty years have been the improved visibility in the northern end and the disappearance of the large clear cuts which marred the attractiveness of the area. No longer does a thick white smokey pall hang over the sound obliterating the sight of the other side. No longer do Vancouver residents complain about the pungent fumes from the pulp mills. Although Howe Sound is primarily designated for recreation, industry successfully coexists in the area. Effluent discharges are closely monitored and treated at source and in a few cases the ideal, non-polluting industry has almost been reached. It is difficult to believe that Howe Sound area is a major timber producing area. Logging

techniques are radically different from those used in the past. Clear cutting is no longer practised in areas visible from the sound; selective logging is used instead. Even in areas not directly visibile from the sound, landscaping techniques are employed to minimize erosion and speed regrowth.

Squamish today is radically different to the scenario anticipated twenty years ago. Then it was envisaged that the town would be a booming exporting centre for coal and timber products as well as having a large industrial complex based on the port. Because the major port developments occurred at Ridley Island and Point Roberts, Squamish diversified its economic base to include other activities such as tourism and salmonid enhancement programs. Because the productivity for coho is extremely high in small streams like the Little Stawamus, the fish produced here are of key signifance to the sport fishing operations in Howe sound and Georgia Strait. In order to maintain this productivity, great care is taken with stream management. Housing and industrial estates are located so that vegetation is maintained around the stream and the impact of urbanization upon the drainage is minimal. Visitors have easy access to a nature park rivalling Richmond's and two ecological reserves, one at the mouth of the Squamish. Squamish also has an unusual tourist attraction with its industrial interpretation centre on the west side of the Mamquam Blind Channel. Here dryland sorting and port operations can be observed. To meet the demands of recreational boaters another public marina has been

established. Some industrial expansion has occurred around the port especially of timber-processing industries. The port area is noted for its effectiveness and high standards of pollution control. The oil slicks, heavy metals and highly corrosive effluents which were a hazard to recreationists and contaminated habitat are now a thing of the past.

A major attraction of the area is the unique islands and their easy accessiblity. Gambier Island is primarily a recreational area with residential development restricted to two camps. Marine parks have been established at Halkett and West Bays with the log booms removed from the area. Improved campsites and trails have been established and once again swimming can be enjoyed due to strict holding tank legislation as well as small treatment facilities for boat sewage on the island. Bowen Island is famous for the environmentally sound way homes have been developed. Often it is hard to notice the homes because they blend imperceptibly into the landscape. Ample public access to the beach front is a key recreational feature of the island. The new provincial park in the centre of the island is yet another interesting area to explore. Within a thirty-minute hydrofoil journey from bustling Burrard Street one can experience the rural quiet of Bowen Island. The western side of Howe Sound appears comparatively undeveloped. Habitat protection is the key objective on the mountainsides between Port Mellon and Woodfibre where steep terrain has discouraged road building and intensive forestry operations. In Gibsons there is

still a seaside village atmosphere. Here access to beach front is maintained while small housing developments have unobtrusively taken place on the hills behind the settlement.

While hiking the Howe Sound Crest Trail or sailing around Anvil Island it is often hard to believe one is not in an almost pristine wilderness area rather than at the doorstep of a busy city.

MOVING FORWARD

The natural and human resources present in Howe Sound can fulfill many of the growing recreation needs of people throughout southwestern British Columbia. It is suggested that this simple goal can best be achieved through an open and cooperative approach to planning that involves government, private and public interest groups. The general principles for management recommended here will help to initiate discussions among managers, the public and planners and lead to an efficient, cost-effective and equitable approach to development.

We suggest the best way to do this is through a series of planning agreements between and among the appropriate agencies. These agreements could be drafted by an interagency committee which would meet initially to coordinate the various components of a plan for Howe Sound. The public should be explicitly involved in both this initial plan and on an ongoing basis for

implementation of the agreements. After the initial planning period is complete a regular review of progress should take place which could provide for any adjustments that may be necessary.

We believe the future of Howe Sound can be a bright one, providing for a productive mix of resource uses while sustaining the viability of the resource base for the recreational needs of British Columbians. However, the timing for adopting the necessary set of policies and management arrangements is important. The opportunity to ensure that Howe Sound meets the highest social needs could be lost in the near future by a series of unrelated decisions which will affect the nature of the sound. The provincial responsibility to coordinate discussions which could lead to the adoption of development principles and management arrangements should be assigned immediately.