Status of Fish Habitat in East Coast Vancouver Island Watersheds

George E. Reid
Fisheries Section, British Columbia Ministry of Environment, Lands and Parks
2080 Labieux Road, Nanaimo, BC, V9T 6J9, Canada
George.Reid@gems8.gov.bc.ca

Tracy A. Michalski
Fisheries Section, British Columbia Ministry of Environment, Lands and Parks
2080 Labieux Road, Nanaimo, BC, V9T 6J9, Canada

Thomas Reid
c/o George Reid, Fisheries Section, British Columbia Ministry of Environment, Lands and Parks
2080 Labieux Road, Nanaimo, BC, V9T 6J9, Canada

ABSTRACT

The Vancouver Island boundary of the Georgia Basin is 1 of the fastest growing areas in British Columbia. The area has an abundance of small, second-order streams, most of which originate in private forested lands, then run through rural and urban environments. We examined the instream habitat of 14 watersheds in that area. We found reduced pool area in 41% of the watersheds, a lack of large woody debris (LWD) in 93%, reduced instream cover in 50%, and excessive fine sediments in 88%. Our analysis shows summer low-flow problems in 155 of 165 streams examined. We found an average of 25.4% development in the 14 watersheds as a result of urban, agricultural, golf course, and/or rural residential land use. We make a number of suggestions for improving the protection of east coast streams, including more public involvement in watershed planning and the development of Official Community Plans (OCPs) and bylaws that provide for the protection of small stream habitat during and after development. We also recommend how volunteers may become involved in long-term protection and restoration of their watersheds.

Key words: fish, habitat restoration, land use, public involvement, small streams, Vancouver Island.

The Georgia Basin of British Columbia is 1 of the fastest growing areas on the continent. More than two-thirds of the population of the province live there, yet the region makes up less than 3% of British Columbia's total area (Owen 1994). By the year 2020, Vancouver Island's population is expected to double, expanding the population to more than 850,000 along the narrow east coast of the island (Owen 1994, B.C. MFCR 1997). The impact on small stream fish habitat, given the island's sheer physical constraints, will be significant.

Over the past decade, the involvement of volunteers in a variety of stewardship initiatives has increased significantly due to growing public concern over deteriorating natural habitats. One government program providing funding and technical support to stewardship projects in the Georgia Basin is the Urban Salmon Habitat Program (USHP). Since its inception in 1995, the program has funded 77 different projects on Vancouver Island, focusing on increasing community awareness, habitat and fish assessment, and stream and riparian restoration.

We insist that stewardship groups undertake fish habitat assessments to identify and prioritize the factors limiting fish production before any restoration is contemplated. Some of the elements contributing to salmonid habitat include: large logs that provide instream rearing during the summer and winter; suitable-size, clean gravel for spawning; and boulders, logs, and roots that provide escape cover (Lister and Genoe 1970, Bustard and Narver 1975, Griffith 1980, Wesche and Rechard 1980, Bisson et al. 1981, Bjornn and Reiser 1991). We have volunteers assess their streams during the low-flow period (August–September). Summer flows below 10% of the mean annual discharge (MAD) result in reduced stream carrying capacity (Tennant 1976). Wickett (1951) showed that smolt production is positively correlated with stream discharge.

We also have volunteers determine the land use adjacent to the riparian zones. Poor land-use practices can result in: vegetative clearing; soil compaction; stream channelization; riparian corridor alterations; chemical pollution; and changes in flow regime (Benke et al. 1981, Booth and Reinelt 1993, City of Olympia 1994). Urban development is of special concern due to the impact of impervious surfaces on small stream habitat. A number of studies show that stream degradation occurs when the amount of impervious area in a watershed exceeds 10% (Lucchetti and Fuerstenberg 1993, Precision Identification Biological Consultants 1997, Green Mountain Institute 1998).

In this study we examined the current state of fish habitat

L. M. Darling, editor. 2000. Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamloops, B.C., 15 - 19 Feb.,1999. Volume One. B.C. Ministry of Environment, Lands and Parks, Victoria, B.C. and University College of the Cariboo, Kamloops, B.C. 490pp.

Table 1. Streams assessed by stewardship groups in 1995 and 1996 using the Urban Salmon Habitat Program Assessment Procedures.

Creek	Stewardship group	Area	Year stream assessed
Ayum Creek	Society for the Protection of Ayum Creek	Sooke	1996
Beach Creek	Qualicum Beach Streamkeepers	Qualicum Beach	1996
Bear Creek	Oyster River Watershed Management Committee	Campbell River	1996
Fairways Creek	Oyster River Watershed Management Committee	Campbell River	1996
Kingfisher Creek	Haig-Brown Kingfisher Creek Society	Campbell River	1996
Little River	Little River Enhancement Society	Comox	1996
Little Oyster River	Oyster River Watershed Management Committee	Campbell River	1996
Nile Creek	Nile Creek Enhancement Society	Bowser	1996
Piercy Creek	Millard/Piercy Watershed Stewards	Courtenay	1996
Scales Creek	Little River Enhancement Society	Comox	1996
Simms Creek	Campbell River Fish and Wildlife Association; Campbell River Guides Association	Campbell River	1996
Thatcher Creek	Nanaimo Fish and Game Protective Association	Nanaimo	1995
Woodhus Creek	Oyster River Watershed Management Committee	Campbell River	1996
Woods Creek	Storie Creek Golf and Recreation Society	Campbell River	1996

and land use in 14 study streams, and flows in 165 watersheds on the east coast of Vancouver Island. We found severe impacts to fish habitat, due to a variety of factors including poor land-use practices. We discuss the implications for salmonid habitat management in small streams including implementing comprehensive new strategies such as publicly supported land-use plans to protect small stream fish habitat. We also recommend stewardship groups and local governments share the responsibility of long-term development, monitoring, and protection of their streams and that senior governments enforce the legislation governing these activities. Finally, we recommend community-focused stream restoration and public awareness programs.

METHODS

Stewardship groups completed 14 USHP fish habitat assessments between 1995 and 1996 using an assessment procedure developed by the Urban Salmon Habitat Program on Vancouver Island (Table 1; Fig. 1; Michalski et al. 1995). The procedure involves collecting data for a number of parameters including: percentage of pools; percentage of instream cover; large woody debris/bankfull channel width (LWD/BCW); percentage of fines; and percentage of wetted area along the entire length of the stream, including tributaries. Instream cover includes large woody debris, boulders, undercut banks, and instream vegetation. We entered the stewardship data into a master database and produced a number of summaries and reach roll-ups for the streams and parameters sampled. We then produced island roll-ups to compare the fish habitat parameters to biostandards for healthy streams (Table 2; Johnston and Slaney 1996).

Tennant (1976) noted that stream width, mean discharge, depth, and velocity vary as a function of the mean annual discharge. He defined MAD flows in terms of impacts to fish habitat (Table 3). We used a provincially modified version of the Tennant Method to analyze 165 east coast Vancouver Island streams and then classified these streams according to Tennant's criteria.

We determined the type and percentage of land use in each of the 14 study watersheds by defining watershed boundaries on large-scale aerial photographs and maps and then digitizing each land use type. (Table 4). We used 1:11,000-scale aerial photographs and 1:5,000-scale cadastral maps for areas where aerial photographs were not available.

We calculated the total amount of impervious area after

Table 2. Biostandards for instream fish habitat parameters (modified from Johnston and Slaney 1996).

Habitat Parameter	Biostandard	Rating
Pools	>55% of reach	Good
	40–55% of reach	Fair
	<40% of reach	Poor
Instream cover	>20% cover	Good
	6–20% cover	Fair
	0–5% cover	Poor
LWD/BCW[a]	>2 pieces/BCW	Good
	1–2 pieces/BCW	Fair
	<1 piece/BCW	Poor
Fines	<10% of area sampled	Good
	10–20% of area sampled	Fair
	>20% of area sampled	Poor
Wetted area	>90%	Good
	70–90%	Fair
	<70%	Poor

[a] LWD = Large Woody Debris; BCW = Bankfull Channel Width.

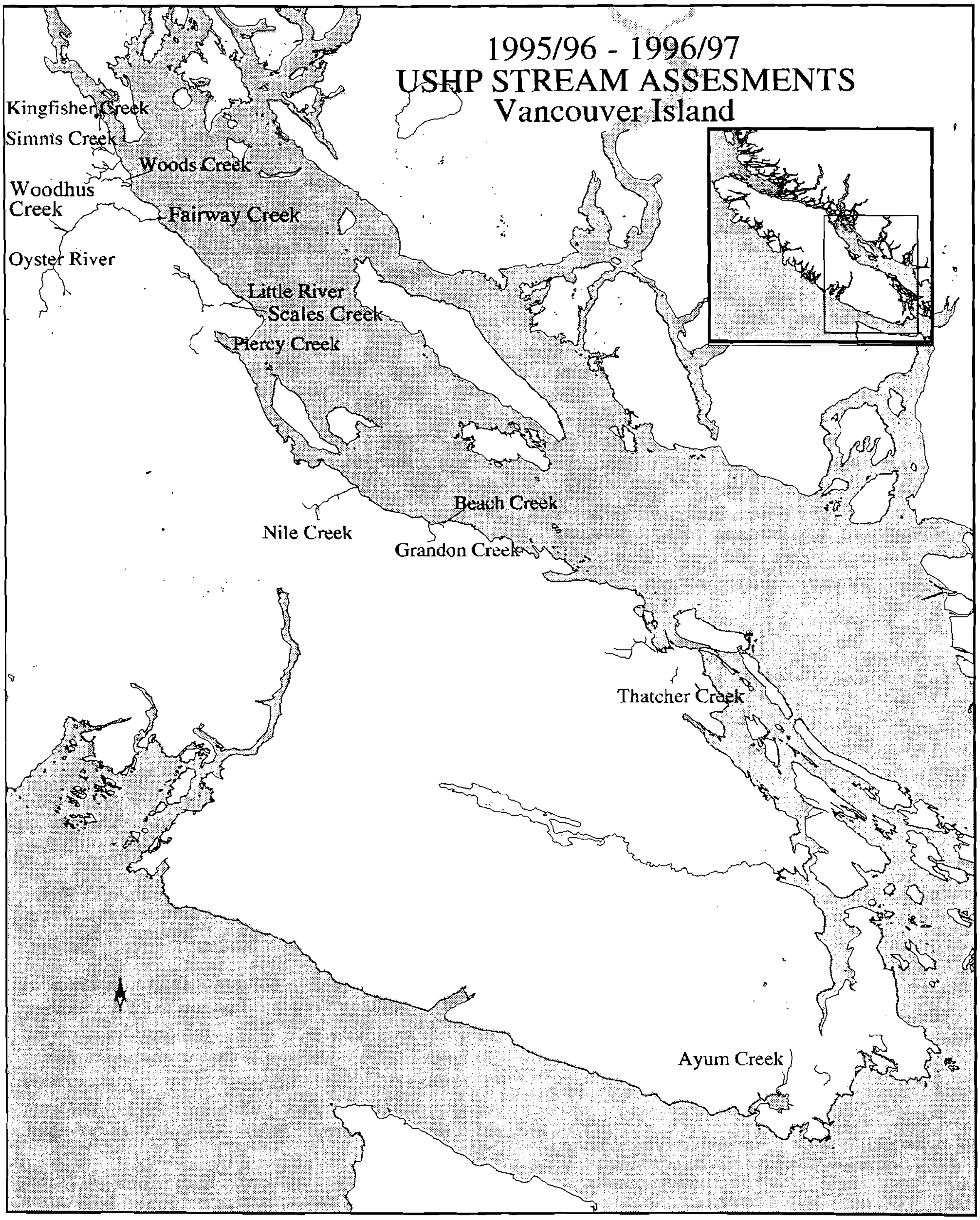


Figure 1. Study location.

Table 3. Instream flow requirements based on the modified Tennant (Montana) Method.

Flows (% Mean Annual Discharge)	Description
30-60% MAD	Excellent spawning/rearing
20-30% MAD	Good spawning/rearing
10-20% MAD	Fair spawning/rearing
5-10% MAD	Poor spawning/rearing
<5% MAD	Severely degraded spawning/rearing

we determined the amount of urban development. Total impervious area is composed of the amount of rooftops plus the amount of transportation links in a watershed (Schueler 1994). Researchers in Washington State showed that road-related impervious area comprised 64–70% of total impervious area in 11 residential, multifamily, and commercial areas (City of Olympia 1994). We used a conservative estimate of 60% to calculate the road component of total impervious area. The impervious area in Washington State associated with rooftops in medium-density, single-family homes ranged from 25% to nearly 60% (Schueler 1994). We used the median of 40% to account for the impervious area related to rooftops. We calculated the total impervious area for the 14 study watersheds as:

Impervious Area (m^2) = $I_{roof} + I_{road}$

% Impervious Area = Impervious Area/Watershed Area

where: I_{road} = 60% of Urban Area; I_{roof} = 40% x (Urban Area - Road Area).

Researchers in Washington developed a stream quality index, which we used to classify the status of stream quality based on the amount of impervious area in each watershed (Table 5; Schueler 1994).

RESULTS

We calculated the average percentage pool area for all assessed streams as approximately 50%, slightly below the biostandard of 55% (Fig. 2). A total of 6 streams, including Ayum, Kingfisher, Piercy, Scales, Simms, and Woodhus creeks, did not meet the biostandard. The remaining 8 streams ranged from 58% pool habitat in Beach Creek to 90% in Woods Creek.

Table 5. Stream quality index based on the amount of impervious area (modified from Schueler 1994).

Percent of impervious cover	Status of stream quality
1–4%	Minimum Impact
5–10%	Stressed
11–25%	Impacted
26–100%	Degraded

Table 4. Land use categories and their descriptions determined for the study watersheds on the east coast of Vancouver Island.

Land Use	Description
Forest	Tree-covered land.
Rural residential	Residential and other buildings in low density.
Urban	Cities, towns, and villages, as well as isolated areas such as manufacturing plants, rail yards, industrial areas etc.
Agriculture	Land-based agricultural activities.
Exposed/logged	
Golf course	Fairways and greens.

The average percent instream cover found in 13 of the study streams was approximately 21%, slightly above the biostandard of 20% (Fig. 2). Thirty-eight percent of the streams had >20% instream cover, while 62% of the streams fell below the biostandard. None of the study streams had <5% instream cover, although the Little Oyster River fell on that border.

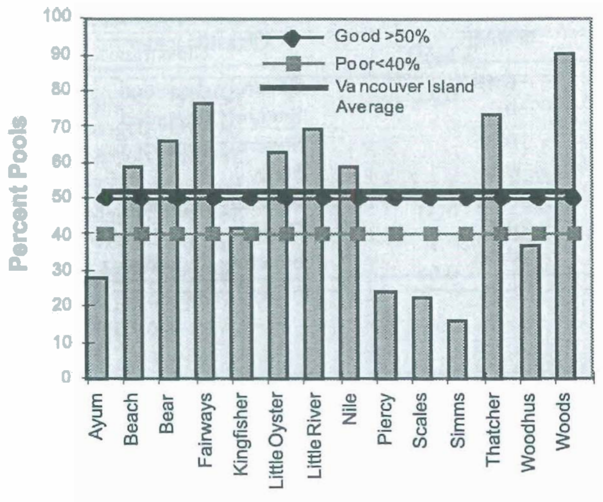
The biostandard for LWD/BCW is 2 (Johnston and Slaney 1996). We calculated the average number of pieces of LWD/BCW at 0.78 (Fig. 2). We found LWD/BCW limiting in all but 1 stream. Ten of the study streams contained <0.5 pieces of LWD/BCW, while 1 creek had <0.1 pieces.

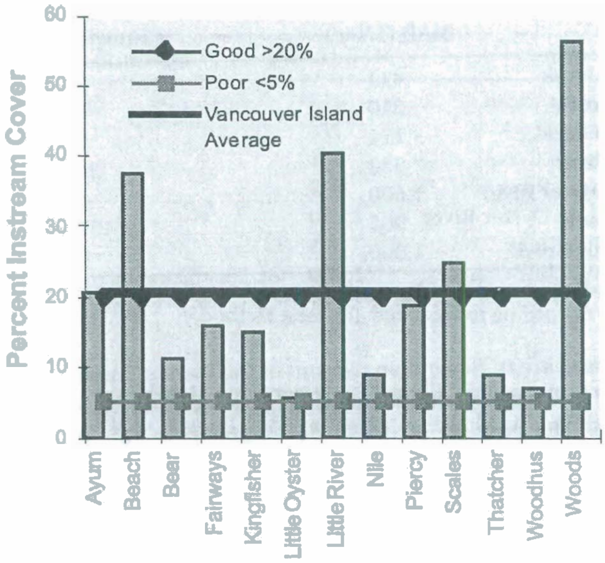
We analyzed the percentage of fines in 8 of the 14 study streams (Fig. 2). The remaining streams had incomplete data for this parameter. We calculated the average percentage fines at 50.2%, well above the biostandard of 10%. Only Ayum Creek had <10% fines, as required for unimpaired salmonid production. We found 95% fines in Beach Creek; >86% fines in Thatcher Creek; and 68% fines in Little River.

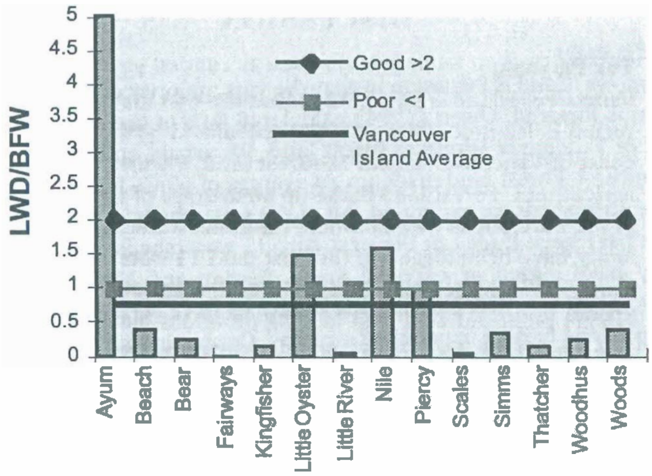
We did not find any streams that met the 90% biostandard for wetted area (Fig. 2). The average percentage wetted area was 64% for the 13 streams examined. Only Fairways, Kingfisher, and Woodhus creeks had >70% of the channel wetted during the assessment. The percentage of wetted area in the remaining 10 creeks varied from 30% in Scales Creek to 69% in Simms Creek.

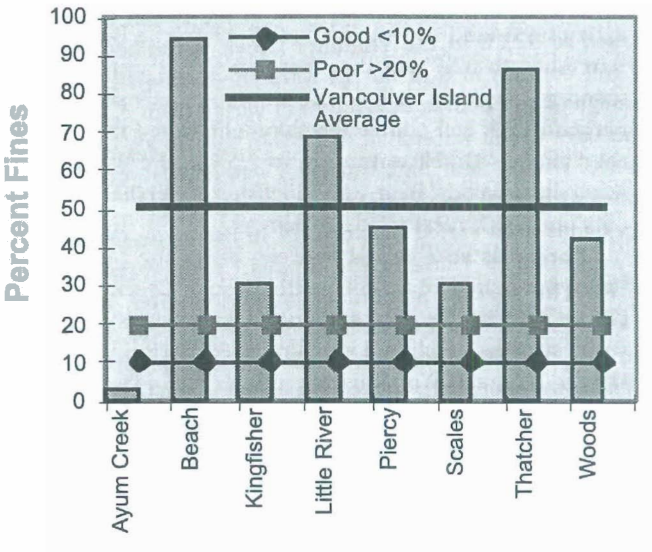
Eighty-two percent of the 165 streams had flows <5% MAD (Fig. 3). A further 11.5% of these streams had flows between 5 and 10% MAD, for a total of 93% with degraded spawning and rearing habitat. Only 6% of the streams we examined had summer flows >10% MAD. Seven of our 14 study streams had a Water Allocation Plan. Five of these streams had flows <5% MAD; 1 had a summer flow of 8% MAD; and 1 had a flow >20% MAD (Table 6).

Forest land was the predominant land-use type in all watersheds (Table 7). The percentage of forested area varied from 42.4% in the Piercy Creek watershed to 99% in the Woodhus Creek watershed. We found 12 streams with logged









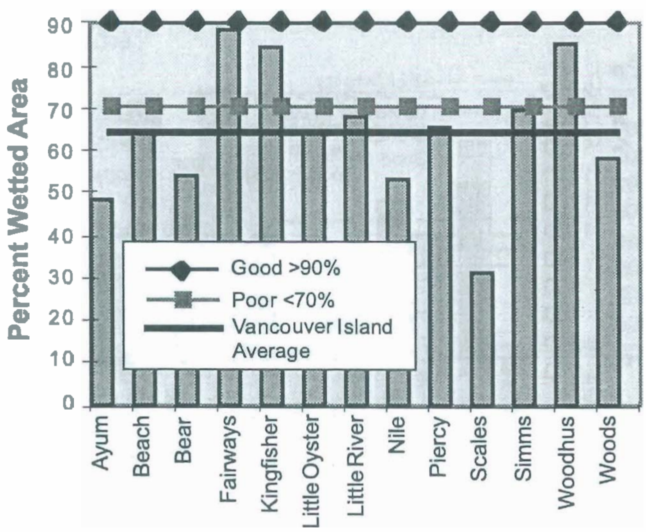


Figure 2. Percent pool area, percent instream cover, pieces of Large Woody Debris/Bankfull Channel Width; percent fines; and percent wetted area in fourteen Vancouver Island streams assessed using the Urban Salmon Habitat Program Assessment Procedures between 1995 and 1996.

Table 6. Mean Annual Discharge (MAD) and low flow measurements for 7 east coast Vancouver Island streams with Water Allocation Plans.

Stream	MAD (L/sec)	Critical flow (L/sec)	% MAD	Classification[a]
Ayum Creek	411	0.9864	0.48	Severely degraded
Bear Creek	310	0	0	Severely degraded
Beach Creek	171	0	0	Severely degraded
Little River	332	26.56	8	Poor
Little Oyster River	1,600	4.96	0.31	Severely degraded
Nile Creek	985	197.99	20.1	Good
Woodhus Creek	1,500	9.9	0.66	Severely degraded

[a] According to modified Tennant Method.

or exposed areas. Seventeen percent of the Woods Creek watershed had logging, which was the highest of all streams examined. The amount of urban development in the study watersheds varied from 0% in the Little Oyster River to 25.8% in Simms Creek. Most watersheds in the study had <10% of the watershed in urban development, but Beach, Piercy, and Simms creeks had >20%. Six of the study streams contained agriculture in their watersheds. The amount of agricultural land use varied from 7.4% in the Beach Creek watershed to 32.7% in the Thatcher Creek watershed. We found golf courses in 6 of the 14 watersheds studied. The percentage of golf course development varied from 3.3% in the Fairways Creek watershed to 7.5% in the Woods Creek watershed. Woods, Bear, and Kingfisher watersheds were the only ones with rural residential areas.

Impervious area varied between 0% in the Little Oyster River watershed to 19.6% in the Simms Creek watershed (Table 8). The average amount of impervious area in all study streams combined was almost 8%. Ayum, Bear, Little Oyster, Nile, and Woodhus watersheds had <4% impervious area. These watersheds have been classified as having minimal impact from impervious area (Table 9). Kingfisher, Little River/Scales, Thatcher, and Woods watersheds had 5–10% impervious area (Fig. 4). We classified the status of stream quality in these watersheds as stressed. Beach, Fairways, Piercy, and Simms watersheds had 11–25% impervious area and we classified these streams as impacted as a result of impervious area.

DISCUSSION

The Problem

Vancouver Island is fortunate in that the vast majority of the region is forested. Owen (1994) calculated 84% of the east coast of Vancouver Island as forest land, 9% urban, and 3% agricultural. Forest land made up an average of 68.2% for all of the watersheds we examined. All of the watersheds in our study have been logged in the past, and 11 watersheds currently have logged or exposed areas. Slaney and Martin (1997) point out that past logging practices have seriously impacted the habitat capacity of streams. Compounding the problem on Vancouver Island is a natural, historic low-flow regime in most small streams (Water Survey of Canada 1975). Our analysis shows summer low-flow problems in 155 of 165 streams. Low flow resulted in our classifying spawning

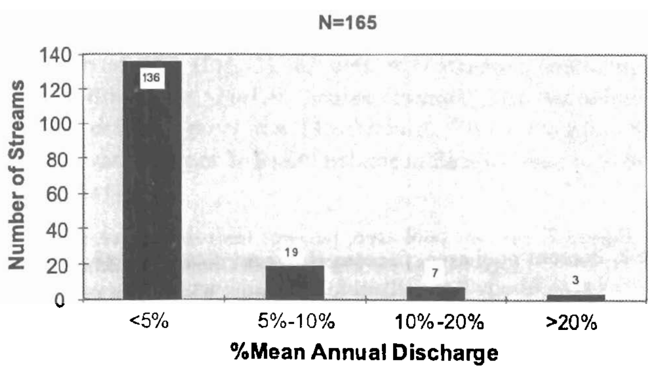


Figure 3. Mean Annual Discharge (MAD) for Vancouver Island streams for which a Water Allocation Plan has been completed.

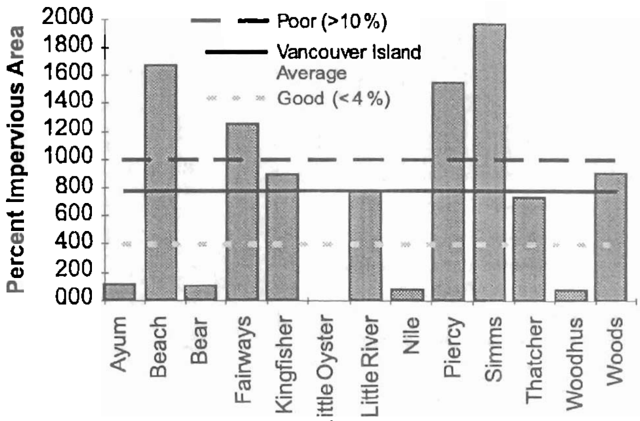


Figure 4. Percent Impervious Area for fourteen Vancouver Island watersheds.

Table 7. Type and percentage of each type of land use in 14 east coast Vancouver Island streams.

Watershed	% of each type of land use					
	Forest	Urban	Exposed or logged	Agriculture	Golf course	Rural residential
Ayum Creek	98.5	1.5	0	0	0	0
Beach Creek	58.1	22.1	7.8	7.4	4.6	0
Bear Creek	59.7	1.3	3.7	19.3	0	16
Fairways Creek	58.3	16.5	5.9	16	3.3	0
Kingfisher Creek	56.6	11.7	8.2	0	7.1	16.4
Little River and Scales Creek	54.9	10.2	9.7	22.3	2.8	0
Little Oyster River	98.8	0	1.2	0	0	0
Nile Creek	88.9	1.2	9.9	0	0	0
Piercy Creek	42.4	20.2	5	32.4	0	0
Simms Creek	60.8	25.8	13.4	0	0	0
Thatcher Creek	52.4	9.6	2.9	32.7	2.4	0
Woodhus Creek	99.0	1	00	0	0	0
Woods Creek	63.9	11.9	16.7	0	7.5	8
AVERAGE	68.6	10.2	6.5	10	2.1	3.1

and rearing habitat as severely degraded in 5 of 7 streams. We conclude that most of the 600 small streams on the east coast of the Island have similar water quantity problems. The consequences of long-term forest development and a natural low-flow regime is that small streams on Vancouver Island have reduced habitat capacity, making them particularly vulnerable to any development within their watersheds.

All sustainability problems are population driven. Urban and agricultural development have among the most extensive impacts on aquatic habitats in North America (Schueler 1991, Mitchell 1996). These land uses can affect flow during wet and dry periods, and can result in stream channelization, reduction in instream complexity, increases in sediment inputs, riparian alterations, water withdrawals for irrigation, compaction of substrate, and chemical inputs (Leopold 1968, Anderson 1970, Brown 1983, Klein 1990). Schueler (1994) examined a number of streams in urbanized areas of King County, Washington and found: they lacked significant pools; were often devoid of large woody debris; the riparian zones were often badly eroded; the bed gravels were generally packed with silts and sand; and the pattern of seasonal high and low flows were more frequent and longer lasting. Mitchell (1996) found that an average of 5 tons of sediment, organic matter, and bacteria per acre per year flow from crop lands to

Table 8. Percentage of impervious area (IA) based on the amount of roof tops and roads contained in land classified as urban in 14 east coast Vancouver Island watersheds.

Watershed	Watershed area (km^2)	Urban area (km^2)	IA due to roads[a]	IA due to roofs[b]	Total IA ($I_{road} + I_{roof}$)	% of watershed in IA[c]
Ayum Creek	13.7	0.21	0.13	0.03	0.16	1.17
Beach Creek	6.3	1.38	0.83	0.22	1.05	16.67
Bear Creek	8.3	0.11	0.07	0.02	0.09	1.08
Fairways Creek	3.6	0.59	0.35	0.1	0.45	12.5
Kingfisher Creek	2.8	0.33	0.20	0.05	0.25	8.93
Little River and Scales Creek	19.3	1.97	1.18	0.32	1.5	7.77
Little Oyster River	42	0	0	0	0	0
Nile Creek	16.9	0.19	0.11	0.03	0.14	0.83
Piercy Creek	7.7	1.56	0.94	0.25	1.19	15.45
Simms Creek	13.8	3.56	2.14	0.57	2.71	19.64
Thatcher Creek	4.56	0.44	0.26	0.07	0.33	7.28
Woodhus Creek	37.1	0.37	0.22	0.06	0.28	0.75
Woods Creek	11	1.31	0.79	0.21	1	9.09
AVERAGE	14.39	0.92	0.56	0.14	0.70	7.78

[a] I_{road} = 60% of Urban Area.
[b] I_{roof} = 40% x Urban Area - I_{road}.
[c] Impervious Area/Watershed Area.

Table 9. Percentage of impervious cover, status of stream quality, and ratings for 14 east coast Vancouver Island watersheds.

Watershed	Impervious area (%)	Status of stream quality	Rating
Ayum Creek	1.17	Minimum Impact	1
Beach Creek	16.67	Impacted	3
Bear Creek	1.08	Minimum Impact	1
Fairways Creek	12.5	Impacted	3
Kingfisher Creek	8.93	Stressed	1
Little River and Scales Creek	7.77	Stressed	1
Little Oyster River	0	Minimum Impact	1
Nile Creek	0.83	Minimum Impact	1
Piercy Creek	15.45	Impacted	3
Simms Creek	19.64	Impacted	3
Thatcher Creek	7.28	Stressed	1
Woodhus Creek	0.75	Minimum Impact	1
Woods Creek	9.09	Stressed	1

aquatic areas. He points out that besides choking aquatic life, these sediments deposit traces of fertilizer, herbicides, and insecticides to the recipient waterways.

Eighty-two percent of the watersheds we examined contained some level of urban development, and 43% of the watersheds had both urban and agricultural land use. Twenty-eight percent of our study creeks were impacted due to impervious surface area >10% and a further 28% were approaching that level. We found that streams had been simplified, resulting in reduced pool areas, a lack of LWD, and reduced instream cover. All but 1 stream had excessive fine sediments (Table 10). The population on the east coast of Vancouver Island is expected to double over the next 20 years. The question is, how do we protect the fish habitat we have left, and can we restore the habitats that are already degraded?

Protection of Small Stream Habitats

Loss of freshwater fish habitat cannot be compensated by quick fixes such as hatchery introductions or localized restoration efforts. We must implement a much more comprehensive approach that focuses on long-term planning, protection, restoration, and public awareness if we want to protect and restore our small stream habitat over the long term. We suggest: 1) planning initiatives that involve local government and local citizens; 2) development restrictions focused on long-term protection and attention to impervious area; 3) new legislation that restricts water extraction when flows are critical; 4) local government responsibility for habitat protection; 5) stronger, mandatory land development guidelines; 6) long-term riparian and instream restoration plans; and 7) public awareness and landowner contact programs.

We suggest that stewardship groups become involved in watershed planning through participation in the development of Official Community Plans (OCPs). We also recommend that volunteers form partnerships with local governments and become involved in the long-term planning of their watersheds by completing watershed management plans. These plans can provide community supported protection and development goals that ultimately become articulated in the OCP.

Development restrictions will help in the long-term protection of small stream habitats. These can be defined through stewardship bylaws that are environmentally focused, yet simple and administratively efficient, directions for small parcels of land (B.C. MELP 1996*b*). The Municipal Act contains provisions for: 1) tree protection/soil removal

Table 10. Status of fish habitat of 14 Vancouver Island watersheds.

Watershed	Percent pool area (<55%)	Large woody debris (<2)	Percent instream cover (<20%)	Percent fines (10–20%)	Percent wetted area (<90%)	Critical flow (<10% MAD)	Impervious surface area(>10%)
Ayum Creek	x				x	x	
Beach Creek		x		x	x	x	x
Bear Creek		x	x	no data	x	x	
Fairways Creek		x	x	no data	x	no data	x
Kingfisher Creek	x	x	x	x	x	no data	
Little Oyster R.		x	x	no data	x	x	
Little River		x		x	x	x	
Nile Creek		x	x	no data	x		
Piercy Creek	x	x	x	x	x	no data	x
Scales Creek	x	x		x	x	no data	no data
Simms Creek	x	x	no data	no data	x	no data	x
Thatcher Creek		x	x	x	no data	no data	
Woodhus Creek	x	x	x	no data	x	x	
Woods Creek		x		x	x	no data	

and deposition/watercourse protection bylaws; 2) zoning bylaws to protect sensitive areas; 3) development variance permits to protect site-specific areas; 4) development permits to protect lands in a natural state, particularly around watercourses; 5) subdivision bylaws to cover protection during construction; and 6) subdivision approval bylaws, which require an approving officer to enforce bylaws.

Impervious area represents the imprint of land development on the landscape (Schueler 1994). Severe changes in hydrology and channel morphology, and a significant and possibly irreversible loss of stream habitat and aquatic system function occurs once a watershed is covered by >10% impervious area (Booth and Reinelt 1993, Precision Identification Biological Consultants 1997, Green Mountain Institute 1998). We recommend that development planning ensure the amount of impervious area be kept to a minimum. Open space plans should be a mandatory part of each development, including provision of stormwater detention areas. These plans should require the developer to preserve an additional percentage of open space to accommodate the residents' future requirements for parks, playgrounds, and other community needs (Schueler et al. 1992). These types of development restrictions are critical if we want to reduce and control the amount of impervious area in a watershed.

The British Columbia Ministry of Environment, Lands and Parks (MELP) recognizes that low flow is a problem on Vancouver Island (B.C. MELP 1996*a*). It is now the policy of the Regional Water Management Branch that, when the natural mean monthly flow falls below 10% MAD, extractive licensed demands will only be allowed for the period when the mean monthly flow is above 60% MAD. This policy has resulted in 1 regional government developing headwater storage for their domestic water requirements and enhancing streamflows at the same time.

In her examination of the Fish Protection Act (FPA), Taves (1998) points out that section 5 of the legislation, which enables the protection of water flows for fish, is entirely discretionary. The Water Manager may or may not consider the impact on fish and fish habitat when making water licensing decisions. This legislation will amount to little, if any, protection for fish. We suggest that a better way to ensure flows for fish would be to elevate the Vancouver Island Regional Water Management policy to that of enforceable legislation. This would ensure flows for fish are recognized as equal to the needs of an expanding human population.

The greatest sediment loads to streams are exported during the construction phase of development (Schueler et al. 1992). It is the regional districts and municipalities that are responsible for approving land developments within their containment areas. However, it is the senior governments that are responsible for protecting habitat during and after development. We recommend that this function become the responsibility of the local governments. This would allow for a collaborative approach between the community stewardship groups and the local council throughout the development approval and construction phases. Local involvement will empower local citizens to protect their streams before any development is approved, and during development. It would also involve citizens in mitigation and restoration projects, which may accompany development. Finally, we contend that federal and provincial agencies should be responsible for enforcing environmental legislation. This would, in effect, make the enforcement body independent of the body approving the land use and development.

Our data shows that current environmental site planning techniques are not adequate to protect streams from the impacts of sedimentation. We recommend that regional districts and municipalities hire technical habitat protection staff to review and prescribe site-specific protection measures to accompany development plans. The cost for this staff should be covered, at least in part, by the developer, but the approval for the protection measures should be through the community. This would again vest the responsibility for environmentally responsible development in the hands of the community.

Currently, a number of management guidelines that apply to development practices are weak and applied inconsistently. Some of these guidelines focus on erosion control, revegetation, and leave-strip widths. For example, leave strips may or may not be required and their widths are currently discretionary and usually <30 m (Chilibeck et al. 1992). We contend that land development guidelines including leave strips must be reviewed and become mandatory. In Washington, researchers recently reviewed and revised their standard Riparian Habitat Area (RHA) widths to between 46 m for perennial or intermittent streams and 76 m for other streams and state shorelines (Knutson and Naef 1997). We must be equally diligent if we want to maintain riparian and small stream habitat structure and function.

Restoration of Small Streams

Loss of fish habitat can not be repaired by engineered structures alone (Booth and Reinelt 1993). This was exemplified in Oregon when the United States Forest Service attempted to restore anadromous salmon and steelhead runs in Fish Creek by installing instream structures to address a lack of pools, only to have the structures wash out during floods (Frissel 1997). Restoration efforts that focused on revegetating harvested slopes and restoring natural hydrographic regimes would have had more long-term benefits.

The long-term debate over the success of installing instream structures continues. Hartman and Miles (1995) found, on average, a 50–55% success rate on structures installed in the early 1980s in British Columbia. Since that time, however, acceleration of stream restoration projects in Oregon, Washington, and British Columbia has resulted in increased knowledge about stream rehabilitation and project success has increased (House et al. 1991, Crispin et al. 1993, Heller et al. 1996, Cederholm et al. 1997). We believe that volunteers can implement successful restoration projects with the technical assistance of senior governments. We recommend that groups undertake habitat pre-assessments to determine what instream and riparian habitat factors are limiting and the appropriate priority for restoring these factors.

The effects of suspended sediment on rearing salmonids are significant. Sediment affects both the water column and the streambed (Griffith 1980). Light penetration to the streambed diminishes with increasing sedimentation, which, in turn, limits primary production and availability of food. Thompson (1972) reported decreasing potential productivity with decreasing substrate particle size, silt being the least productive. Salmonids are sight feeders and Bachman (1958) observed the cessation of feeding by cutthroat at turbidity levels of 25 ppm. Herbert and Merkens (1961) report that sediment levels as low as 90 ppm can adversely affect the survival of trout. Perhaps the greatest impact of sediment is on eggs and emerging fry. Bjornn (1969) and McCudden (1977) showed that the percentage of fine sediment in the gravels prevented the emergence of chinook and steelhead fry. When sediments reached 20–25% fines, emergence dropped from about 80% to <10%.

Sediment deposition is a natural process that takes place during periodic flooding, but accelerated upland erosion can increase sediment deposition in streamside areas because of downslope movement of dislodged soil. Riparian zones exert a direct biological, physical, and chemical influence on the stream (Connin 1991). A well-maintained riparian area may fill with sediment, but its eventual release is slow and gradual, and the damage to the stream habitat is minimal (Ruffin 1998). We suggest that riparian zones must be a priority for restoration if we want to minimize sediment inputs from urban and agricultural development. Eroding and altered stream banks must be replanted to ensure that sediment recruitment is minimized. Bioengineering solutions can be adopted in many soil stabilization and erosion control situations. Advantages of bioengineering include: low initial cost and lower long-term maintenance cost; low maintenance of live plants; environmental benefits to wildlife habitat; water quality improvement; improved aesthetics; improved strength over time as root systems develop; and compatibility with environmentally sensitive sites or sites with limited access.

We recommend that stewardship groups complete detailed riparian assessments of their watersheds when they find that the percentage of sediment in their streams exceeds 10%. These assessments should: 1) identify all sediment sources; 2) prioritize stream bank locations for restoration; and 3) suggest appropriate, preferably bioengineered, solutions. Once a riparian restoration assessment is in place, the stewardship group can develop a riparian restoration plan defining long- and short-term goals. The plan must include long-term riparian zone monitoring to ensure the integrity and maintenance of this critical component of fish habitat.

Forty-three percent of the 14 Vancouver Island streams we examined were pool-limited. Pools are a preferred macrohabitat type for coho juveniles in British Columbia (Glova and Mason 1976, Hartman 1965). Griffith (1980) investigated the summer habitat requirements of sympatric populations of cutthroat and coho in Bush, Holland, and Ayum creeks and found that the highest biomass usually occurred in pools. Nickelsen and Reisenbichler (1977) showed that 80% of the variation in coho standing crop in some Oregon streams was explained by pool area. Michalski and Reid (1998) found coho preferred artificial pool habitat with depths >30 cm.

There are a variety of ways to construct pool habitats, but volunteers must take care when designing a pool creation project (Cederholm et al. 1997, Slaney et al. 1997, Allan and Lowe 1997, Newbury et al. 1997). We do not recommend digging instream pools with a machine because this destabilizes the stream bed. Pools constructed this way also usually fill in. Over the past year, we have monitored machine-dug pools and found that 75% of them have filled in and they are causing erosion in a number of locations. We recommend that volunteers consult professionals, including senior government technical staff, for advice before any instream work is contemplated.

Instream cover provides fish with refuge from predators. It also increases the carrying capacity of streams by increasing habitat complexity. Prime cover for coho includes overhanging vegetation, undercut banks, rootwads, and log accumulations (Griffith 1980). Wesche and Rechard (1980) described trout habitat as, among other things, object oriented. Bustard and Narver (1975) showed that as water temperatures dropped to 47–35°F, juvenile coho and steelhead moved into deeper pools containing upturned tree roots and logs. Research in Oregon shows that the addition of conifer logs to debris-poor streams can increase salmonid smolt production several fold (Murphy 1995). The addition of debris in the Clearwater River, Washington produced a 5-fold increase in winter survival of juvenile coho (Cederholm et al. 1988).

In small and intermediate streams, LWD contributes to channel stabilization, energy dissipation, and sediment storage (Cederholm et al. 1997). Bilby and Ward (1991) found a positive correlation between the pool area of a stream and the volume of the LWD forming the pool. LWD promotes the storage of sediment and traps fish carcasses, which provide a source of nutrients and carbon (Slaney et al. 1997). Peters et al. (1992) found that introduced woody debris is at least as effective as natural debris in attracting and sustaining juvenile coho salmon during summer. Enhancing LWD can be done at relatively low cost; however, we recommend that volunteers have expert advice to ensure that LWD placements and log sizes are appropriate.

Finally we suggest that volunteers augment restoration projects with public information programs. Many stewardship groups working on stream assessment and restoration activities have been confronted with a general lack of knowledge on the part of watershed residents about the importance and sensitivity of streams (Shepp and Cummins 1997). Often the general public does not understand their connection to small streams and the associated ecosystem. Yet the understanding and support of watershed residents is critical to the success of long-term restoration and protection efforts We suggest that volunteers host neighbourhood information sessions and/or landowner contact programs before and during restoration projects. Information on the project, as well as on the importance of riparian and instream habitat, should be emphasized. Discussions of concerns about fish habitat protection, including private land stewardship, should also be encouraged and facilitated.

Increasing the public's knowledge and appreciation about the importance and fragility of small stream habitats may well be the most important activity that community stewards can undertake. It may also tip the scales from continued deterioration to long-term protection and restoration of east coast Vancouver Island streams.

ACKNOWLEDGEMENTS

We sincerely thank the stewardship groups that conducted USHP fish habitat assessments on their creeks. The dedication of these volunteers to identifying the factors limiting fish production has lead not only to comprehensive, prioritized restoration plans, but also to a much better understanding of the status of fish habitat on Vancouver Island.

We also thank L. Boykiw and D. Hart for their diligence during the data analysis, P. Wipper for his advice regarding impervious surface area in Nanaimo, and D. Fetherston for his assistance in the preparation of the figures for this report.

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