Island Geoscience

Geoscience issues as they relate to water, land and air protection on Vancouver Island

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Fall is here…

Well fall is here already and with it comes the self imposed deadline of another issue of Island Geoscience. As painted leaves begin to fall and the salmon work their way up streams already filling with autumn rains, it seems an appropriate time to consider again the role of riparian vegetation to streams. A brief discussion of riparian vegetation and channel form follows. It comes as a result of the Geomorphology Vancouver Island project which is not yet available on the web, but that will be soon (limited only by my ability to write up the results in a timely manner).

Building on the water-land interface in this issue, we have an article written by British geomorphologist, Dr. Mark Lee, on coastal shoreline erosion, and more about the Horne Lake shoreline erosion study.

There are other tidbits and announcements, so have a look.

If you have any comments on any of the articles, or have questions about anything within this newsletter, please contact me at:

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If you have recent work that seems to fit the overall theme of this newsletter, let me know and I'd probably be happy to include it.

Past issues of Island Geoscience are catalogued at the Ministry of Forests Library: http://www.for.gov.bc.ca/hfd/LIBRARY/Island_Geoscience.htm

We're all inundated with Email. If you are getting this newsletter and *do not* want it, please send me an Email at the above address and let me know. I will take you off the list. On the other hand, if you know someone who would like to be on it, again, please let me know.

Lastly, I wanted to express my sincere thanks to all the folks who sent me feedback on the previous issue, or passed this newsletter on to a friend or colleague.

Until winter,

Rick.

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Protecting our lakeshores for fish and people: Assessments and tools for shoreline erosion on small lakes with controlled outlets

PD Law and RH Guthrie

Note: This topic was mentioned last issue as well; however, we are substantially further along in the process. This is a copy of the abstract from the recent North American Lake Management Society conference in Victoria. We continue to work on writing up the results. –RHG

British Columbia contains many small lakes with controlled outlets whose water levels fluctuate considerably as a result. On Vancouver Island, rising lake levels are typically related to winter storm events and result in potentially severe shoreline erosion scenarios. Development of residential properties along those self-same shorelines is placing increasing pressure upon natural riparian processes, water quality, fish and fish habitat. Landowners that construct protective measures may destroy much of the natural habitat and landscape that makes the lake appealing in the first place, and substantially impact the foreshore's biological characteristics. Lakeshore protection, however, is typically not a one size fits all solution. Erosion hazard varies substantially around the lake based on several factors including slope, material type, cohesion/compaction, and wind exposure. The biological factors of a particular shoreline also vary with the extent of the littoral zone, shoreline complexity and riparian vegetation. We demonstrate a hazard mapping scheme along with a biological sensitivity rating that can be used to select an erosion protection prescription. Prescriptions come in the form of a conceptual toolbox that considers both the necessary protection for infrastructure as well as the preservation of biological values. The scheme was developed for Horne Lake on Vancouver Island, but is portable and intended for use on other lakes around British Columbia. It is hoped that the toolbox approach will assist landowners and the agencies involved in shoreline development approvals determine an appropriate level of erosion protection, while supporting the biological integrity of the lake.

Cliff Recession and Beach Volumes
Mark Lee

It has long been recognized that beaches control wave energy dissipation on the foreshore and, as a result, can provide protection from shoreline erosion. The nature of this relationship has been the focus of recent research on the Suffolk coast, England. Here, the 10-15m high cliffs are developed in a varied sequence of Pleistocene Norwich Crag sediments, including weak sands and gravels (Westleton Beds) and clays (the Easton Bavents Clay), overlain by later Kesgrave Formation fluvial sands and gravels. The cliffline is unprotected by sea defences and is fronted by a sand and shingle beach. Average recession rates in excess of 5m/year have been recorded over the last decade.

The relationship between the average beach volume (measured as the beach profile area above High Water Mark – the "*beach wedge*") and annual cliff recession rate has been established from detailed analysis of beach-cliff profile surveys undertaken twice a year (winter and summer) since 1992. Each survey profile was analysed to determine:

- *cliff recession*; calculated as the change in position of the cliff top between survey dates;
- *average annual recession rate*; the cumulative cliff top recession (1992-2003) divided by the number of years in the record;
- *beach wedge area*; calculated for each SDMS profile as a triangle defined by the width and maximum height of the beach above MHWS (1.1m at Southwold; 0.9m at Lowestoft);
- *average beach wedge area*; the sum of the beach wedge area for each winter profile (1992-2003), divided by the number of years in the record.

The average beach wedge area and recession rate for each of the profile sites is plotted on Figure 1. The results suggest an exponential relationship:

Recession rate = $13.997e^{-0.1136x}$ where x is the beach wedge area.

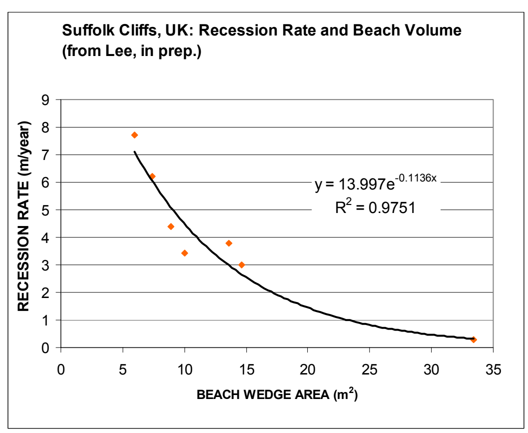

Figure 1. Beach wedge area and average coastal recession rate (from Lee, in preparation).

This relationship provides the basis for predicting the effects of changing beach conditions on cliff recession rates. For example, Table 1 (below) provides an indication of the increase in recession rate that could be expected with particular beach level changes (10-25% depletion).

Dr. Mark Lee is an engineering geomorphologist based out of York in the UK. His tremendous experience in applied geomorphological problems, both from a research and an industry perspective is reflected in his work. He is the author of several publications including two books (with DKC Jones): Landsliding in Great Britian and most recently Landslide Risk Assessment (reviewed in this issue). His research on coastal erosion is both interesting and relevant to British Columbia where many of our shorelines are receding in the face of continued wave erosion against Pleistocene cliffs such as the Quadra Sands.

Dr. Lee offered to write this article when I suggested that I would review his book for this issue. It is interesting to speculate the effects of climate change and rising sea (effective loss in beach wedge area) level on erosion rates for coastlines world-wide. If you have an article that you'd like to contribute to the newsletter, please contact me at the Email address above. -RHG

Table 1 Suffolk cliffs: Predicted Effect of Beach Depletion on Recession Rate

Initial Beach Wedge Area (m^2)	Depletion	Predicted recession rate (m/year)	Recession increase factor
10	0	4.5	
	10%	5.0	1.12
	25%	6.0	1.33
20	0	1.4	
	10%	1.8	1.26
	25%	2.5	1.76
30	0	0.5	
	10%	0.6	1.41
	25%	1.1	2.34

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Riparian vegetation and channel form on Vancouver Island
RHG

There are several reasons to consider the importance of riparian zones around rivers. Riparian zones provide a biological function on the critical interface between terrestrial and aquatic ecosystems: cover for small and large animals, food and nutrient replenishment for aquatic systems (insects and organic litter), shade (particularly to smaller order streams), wood recruitment and habitat complexity. Riparian zones also provide a geomorphological function that varies depending on the river size, but includes channel complexity, channel stability, and to a limited extent, may include channel form.

A recent paper by Burge (2004) examined differences within and between single and multithread channels. Burge (2004) reported that at the pattern scale, single channels and multi-thread channels could be differentiated primarily by discharge and total stream power. Stream power is essentially the relationship between discharge and gradient; its relationship to channel form was previously examined by Church (1992) among others. Church graphed the general relation between channel form and stream power (Figure 1).

Experience on Vancouver Island, suggests that there is considerable morphological variation in rivers, and that some are more vulnerable to braiding than others. Consequently, we plotted the lower alluvial reaches of 42 rivers on Vancouver Island with discharges across two orders of magnitude against Church's (1992) criteria. The results are also plotted on Figure 1.
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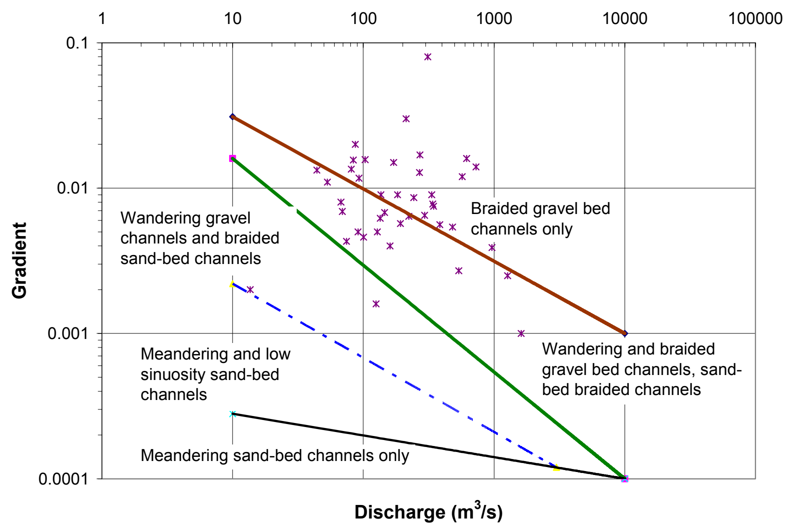

Figure 1. Vancouver Island streams plotted against Church's (1992) channel form criteria.

The initial result suggested that instead of a large morphological variation, the rivers examined were clustered around the upper limit of single thread channels. As mentioned previously, experience indicated this was probably true for some rivers; however it was not the rule. Air photograph interpretation with limited field checking was conducted for each of the rivers in an attempt to determine the extent to which they were actually vulnerable to wandering or braiding. The results of the study were unequivocal. Streams on Vancouver Island are *vulnerable* to braiding and wandering within their *active* floodplain subject to other *geomorphic controls*. The three key components are italicized, and we'll deal with each in reverse order.

Geomorphic controls were critical on all streams. It turns out that for Vancouver Island, based on the 42 rivers assessed, streams were commonly constrained by bedrock and large glaciofluvial deposits that were more compact than the recent alluvium of the floodplain. While the bedrock limiters were expected the glaciofluvial response was more surprising. Perhaps this is because experience in the field indicates that the glaciofluvial deposits are often under attack by river channels and represent massive sources of sediment. However, they also tend to be at higher elevations than the floodplain and sufficiently resistant enough to develop steep faces; both characteristics limit channel movement.

The *active floodplain* is meant to represent the non-cohesive, non-compacted alluvial portion of the floodplain and actually includes areas that are geomorphologically suspended or dormant. In essence, anything that has been active floodplain in the last few thousand years, under climatic conditions similar to what we experience today. This is the portion of floodplain that is typically mapped as Fluvial in a terrain mapping exercise.

The most interesting result of this project is the notion of *vulnerability*. Vancouver Island streams are not automatically multi-threaded or braided despite their plotting position even when not physically constrained by bedrock or glaciofluvial terraces. They appear to be at or near a threshold of stability within their own banks and once disrupted, remain unstable for long (in human terms) periods of time. That stability is a function of the stream inputs including water, sediment load, and importantly, bank stability. Millar and Quick (1993) proposed a parameter Φ' to quantify the effects of bank vegetation on stability and related it to, among other things, stream width and depth ratios. Eaton et al. (2004), Millar (2000) and Millar and Quick (1993) have shown that bank vegetation exerts significant control on alluvial channel river patterns, including the transition between single and multithread varieties.

Coupled with Figure 1 and the results of the air photograph interpretation from this study, the obvious conclusion is that the riparian vegetation plays a fundamental role in the stability of alluvial portions of Vancouver Island streams. Further, the loss of that vegetation can change the dynamics of river channels such that they move into an active multi-channel regime from which they are slow (several decades) to recover. The Eve river confluence with the Adam is an excellent example.

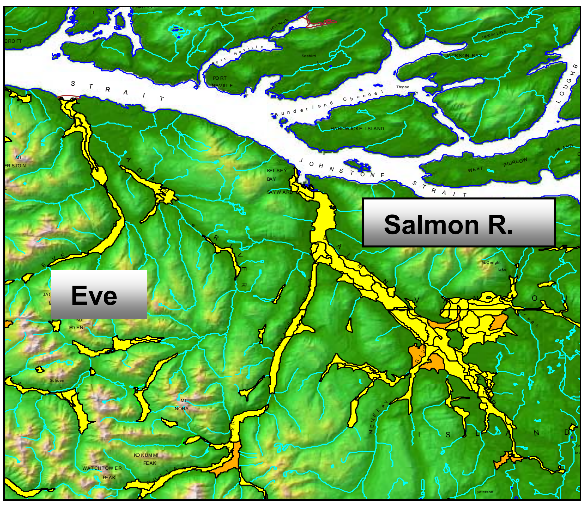

Figure 2. A portion of Vancouver Island showing the areas (in yellow) vulnerable to destabilisation following riparian disturbance. Orange polygons indicate glaciofluvial deposits and often relate to long term sediment sources. Yellow polygons that narrow are geomorphologically constrained.

On a positive note however, the vulnerable areas are manageable and already mapped Island-wide at 1:50,000 scale. This information will be publicly available (winter 2004/2005 is the current target) on the Community Mapping Network as part of the Geomorphology Vancouver Island project. In the meantime, look to your local terrain maps.

Burge LM. 2004. Testing links between river patterns and in-channel characteristics using MRPP and ANOVA. Geomorphology, 63, 115-130.

Eaton BC, Church M and Millar RG. 2004. Rational regime model of alluvial channel morphology and response. Earth Surfaces Processes and Landforms, 29, 511-529.

Millar RG. 2000. Influence of bank vegetation on alluvial channel patterns. Water Resources Research, 36, 1109-1118.

Millar RG and Quick MC. 1993. Effect of bank stability on geometry of gravel rivers. Journal of Hydraulic Engineering, 119, 1343-1363.

Book Review: Landslide Risk Assessment by EM Lee and DKC Jones

(published by Thomas Telford Ltd., London, 2004)

For those of us in the geoscience field, the 2005 International Conference on Landslide Risk Management is coming to Vancouver shortly (http://cgs.ca/2005ICLRM/) and there is every reason to believe that it will be a great event. As we try to get up to speed on landslide risk, the book 'Landslide Risk Assessment' by Lee and Jones should be a required part of any reading list. Lee wrote one of the papers in Cruden and Fell's classic 1997 book. This new book, however, is substantially different in that it is not a collection of papers, but instead offers a complete treatment of landslide risk assessment from a single perspective.

While not a manual, it is comprehensive, beginning with clear sensible definitions of hazard and risk and related terms. It continues with philosophical discussion of the framework and role of risk and risk assessments including principles of uncertainty and risk as a decision making tool. Chapter 2 of 7 looks at landslide hazards, investigation, typology, hazard model construction and uncertainty. Qualitative and semi-quantitative risk assessment including scoring, matrices and relative ratings are discussed in the third chapter, followed by landslide probability estimation in the fourth. The latter considers expert judgement, historical frequencies, simulation models, stability analysis and so on. Estimating the consequences, the fifth chapter, examines our framework for adverse consequences and offers concrete examples from determining elements at risk to forming complete multiple outcome consequence models. In chapter 6, Lee and Jones address risk quantification, individual to societal, with and without management options. Finally, the authors consider in their last chapter, moving toward management strategies.

The book weighs in at about 450 pages; the writing style is enjoyable to read and the commentaries are thought provoking and well articulated. I have already incorporated some of the information into my regular work.

This book is supposed to be available through ASCE press; however, I've not had success finding it on their site. Perhaps it is too new. In either case it can be purchased from the UK at: http://www.ttbooks.co.uk/bookshop_main.asp?ISBN=0727731718

Recent research:
Guthrie, R.H. and Evans, S.G. 2004. Analysis of landslide frequencies and characteristics in a natural system, coastal British Columbia. Earth Surface Processes and Landforms, 29(11):1321-1339. http://www3.interscience.wiley.com/cgi-bin/abstract/109594946/ABSTRACT

Useful links:
Community Mapping Network: http://www.shim.bc.ca/
USDA manuals – field manuals related to all sorts of topics in soils, geology, hydrology and environmental engineering: http://www.info.usda.gov/CED/

Next Issue:

We'll begin to look at a study (again part of the Geomorphology of Vancouver Island work) that examines differences in type, character and frequencies of landslides around Vancouver Island.

Until then!

-RHG

Editor's note: If you have an article or research paper that you would like to see here next time, please let me know at richard.guthrie@gems6.gov.bc.ca