Analysis of Riparian Restoration techniques on Biodiversity: Use of Invertebrate Indicator species to Determine Appropriate Restoration Options for Ecological Recovery of Riparian stands.
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Introduction

- Riparian forests make up a significant component of the productive forest in B.C. that is protected at some level from harvesting
- Objectives of protection include provision of biodiversity and landscape connectivity, as well as protection of salmon and trout habitat
- Guidelines with regards to methods for logging riparian sites after the 1980s
- In the Kennedy Flats Watershed of West Vancouver Island, historical harvesting practices e.g. cross-stream yarding and removal of riparian vegetation and trees have severely and negatively impacted riparian ecosystems
- 1988 Coastal Fisheries/Forestry Guidelines & 1995 Forest Practices Code. 1995 Clayoquot Sound Scientific Panel Recommendations. 1997 management of parks for "ecological integrity".
- Current timber harvesting regulations in British Columbia require reserve zones of riparian vegetation adjacent to most fish-bearing streams BUT post-harvest stand development has often failed to recreate the complexity of the original stands

Introduction contd.

- Interfor and Western Forest Products Inc. have been instrumental in the development of riparian restoration techniques designed to introduce old-growth attributes into riparian habitat
- It is proposed within Interfor's Forest Stewardship Plan to commercially thin 2nd growth riparian areas to accelerate old growth characteristics
- This project was carried out to evaluate riparian restoration treatments on biodiversity within second growth stands in the Kennedy Flats region, Clayoquot Sound, Vancouver Island
- Epigaeic carabid beetles were used as our biodiversity indicator species

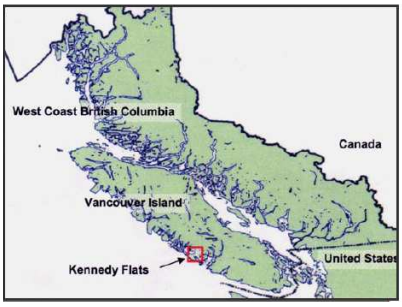
Objectives

- To assess the response of site-level biodiversity to riparian restoration treatments carried out in 4 sites in the Kennedy Flats, Clayoquot Sound, West Vancouver Island
- Silvicultural treatments were designed to introduce old-growth attributes into riparian habitat, as well as to enhance both structural diversity and use of the forest by wildlife.
  - Treatments: thinning, brushing & planting
  - Wildlife features: topping, top-girdling, cutting slots, slits & holes in trees, wound-producing cuts to introduce rot, & the making of small dens by hollowing tree trunks & downed logs

Study Sites

- Treated riparian blocks were located adjacent to Kootowis Creek, Lost Shoe Creek, and Swan Lake & paired with appropriate control sites
- Lost Shoe - thinning of over mature alder overstory to improve conifer regeneration, and to improve conifer stocking as preferred source of LWD
- Kootowis - thinning overstocked conifer stands, releasing conifers suppressed by overstory deciduous trees, & replanting with preferred riparian tree species, was the rapid production of adequate LWD and CWD
- Swan Lake –thinning, planing, wildlife features, aim was introduction of old-growth characteristics.
- Two old-growth riparian sites were also chosen for comparative purposes.

Study Area



Wildlife Treatments- Kootowis




Wildlife Treatments- Kootowis


Wildlife Treatments- Swan Lake




Wildlife Treatments- Swan Lake


Specific Objectives were to:

- Compare carabid beetle communities of treated and untreated buffers, and compare these with old-growth control communities
- Examine small mammal and salamander usage of biodiversity features introduced into treated stands
- Compare understory vegetation of treated and untreated buffers, and compare these with old-growth control vegetation

Biodiversity Responses

- Biodiversity responses were assessed using an invertebrate indicator species (carabid beetles), with focus on relative abundance of old-growth specialists
- We assessed biomass and species assemblages of carabid beetles in treated vs. untreated sites
- We compared vegetation among the sites, and small-mammal and salamander usage of artificial dens and cut logs in the treated sites
- Characterization of the assemblages in treated versus untreated riparian buffers aimed to identify whether silvicultural treatments are successful in providing old-growth attributes to the riparian forest
- Results should provide a valuable reference for selecting and integrating restoration options for ecological recovery of riparian stands

Old-growth & Forest specialists

Forest Generalists

Disturbance specialists

Methods

- Carabid beetles were trapped using 21 pitfall traps in each of nine riparian sites
- Three transects were set up in each site, running parallel to the stream course and at varying distance from the stream (5 m, 15 m and 25 m
- A total of 7 traps were sampled from each transect. 18 pitfall traps were sampled from each of the two old-growth blocks each month
- In total, 176 pitfall traps were sampled every month between June and September

Results

- Carabid beetles were identified to family or genus, and by-catch was identified to order
- Overall, a total of 5836 carabids were captured, from 15 carabid species
- The 2 most abundant species - *Pterostichus crenicollis* Le Conte & *Scaphinotus angusticollis* (Fischer von Waldheim), both forest specialists
- Different sites were dominated by one or the other of these species, and communities along the three riparian zones differed.
- Kootowis sites -dominated by *P. crenicollis*
- Lost Shoe & Swan Lake communities had higher proportions and biomasses attributable to *S. angusticollis*
- May be related to vegetational differences: the latter two sites were dominated by Coastal western hemlock, while the former was planted with offsite Douglas-fir in 1970s

Results

- The invertebrate communities of the riparian sites showed differences to the communities of many of the sites previously sampled on Vancouver Island
- In most Vancouver Island forests, (dry or wet variants)- dominant species is *Scaphinotus angusticollis*, a forest specialist
- In Kennedy Flats we caught 3141 *Pterostichus crenicollis* versus 1354 *S. angusticollis*
- *P. crenicollis* has been shown in other studies in Oregon to be one of the strongest indicators of the immediate (< 5m) streamside community (Rykken et al. 2007)

Results

- Treatments resulted in a reduction in the proportion of *P. crenicollis*, and an increase in the proportion of other species.
- Compositional changes in the sites as a result of treatments varied among the different sites.
  - Treatments at Lost Shoe resulted in a higher proportional catch of *P. algidus*
  - Treatments at Swan Lae led to increased proportional catch of *Zacotus matthewsii, P. lama*, and *S. angulatus*
  - Treatments at Kootowis led to increase in the proportion of the catch made up of *S. angusticollis* and *S. marginatus*
- Riparian restoration treatments in the different sites did not produce identical changes in the different communities

Results

- Evidence of riparian community e.g. *Leistus ferruginosus*, found only at Lost Shoe, is a species known to have strong associations with riparian areas, and *Agonum affine*, another hygrophilous species, which was only found in the treated site at Swan Lake
- Consistent differences in the species assemblages and abundance at the different transect locations could not be discerned, suggesting that the communities within 25m of the stream are relatively uniform within a single site

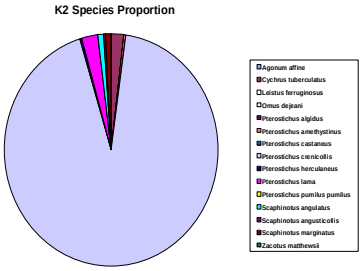
Results

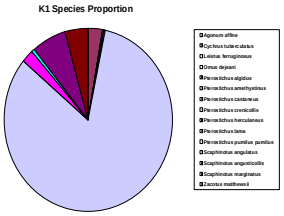
- Diversity and evenness were always lower in the control sites than in the treated sites
- Thus, treatments that open up the canopy,and reduce the shrub layer appear to result in new carabid species moving into the sites- resonant of a more immature community?
- BUT 2 key findings not in accord with this were the noted higher proportional catches of both the old-growth specialist *Zacotus matthewsii* and the forest specialists *S. angusticollis, S. marginatus and S. angulatus* in the treated sites over control sites

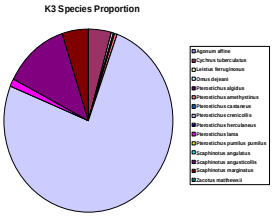
Objective 1: compare carabid beetle communities of treated and untreated buffers, and compare these with old-growth control communities.

Species Name	Sum	K1	K2	K3	LS1	LS2	SL1	SL1 no T1	SL2	R1	R2
Pterostichus crenicollis	3141	827	529	386	218	371	265	80	114	215	216
Scaphinotus angusticollis	1354	69	1	64	325	289	248	209	182	145	31
Pterostichus algidus	329	0	0	1	285	29	6	4	0	6	2
Zacotus matthewsii	205	0	0	0	93	75	7	4	0	24	6
Cychrus tuberculatus	191	28	11	23	16	34	29	18	29	13	8
Pterostichus lama	110	21	15	7	3	3	13	11	7	37	4
Scaphinotus marginatus	84	43	5	25	1	4	0	0	1	4	1
Pterostichus amethystinus	32	2	1	4	1	5	5	4	9	3	2
Agonum affine	20	0	0	0	0	0	20	1	0	0	0
Scaphinotus angulatus	15	5	5	0	2	0	3	0	0	0	0
Leistus ferruginosus	10	0	0	0	4	6	0	0	0	0	0
Pterostichus herculaneus	6	1	1	0	2	0	0	0	0	1	1
Pterostichus pumilus pumilus	5	0	0	0	2	0	0	0	0	3	0
Omus dejeani	2	1	0	1	0	0	0	0	0	0	0
Pterostichus castaneus	1	1	0	0	0	0	0	0	0	0	0

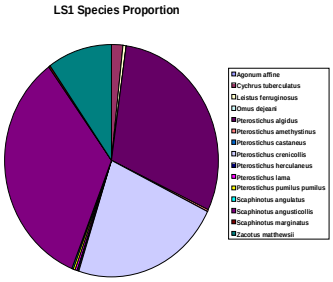
Koootowis Species Proportions

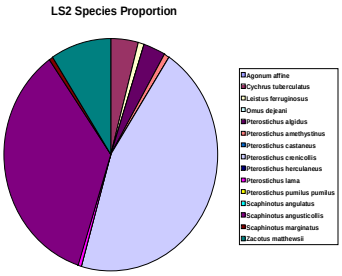






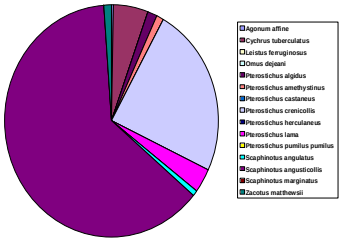
Lost Shoe Species Proportions



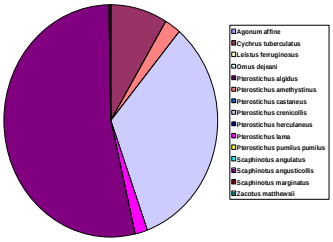


Swan Lake Species Proportions

SL1 No T1 Species Proportion

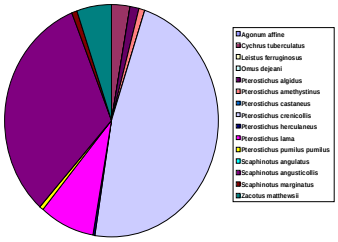


SL2 Species Proportion

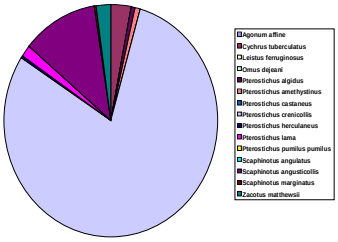


Old Growth Species Proportions

R1 Species Proportion



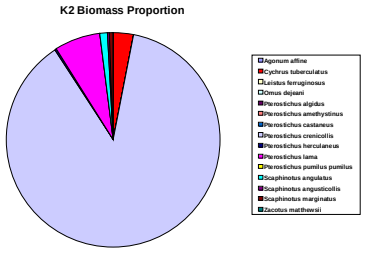
R2 Species Proportion

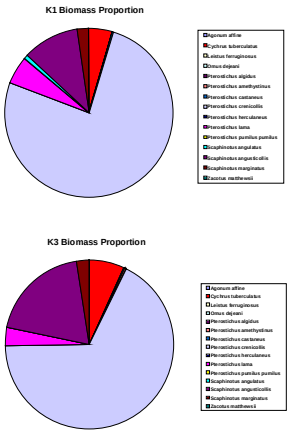


Biomass

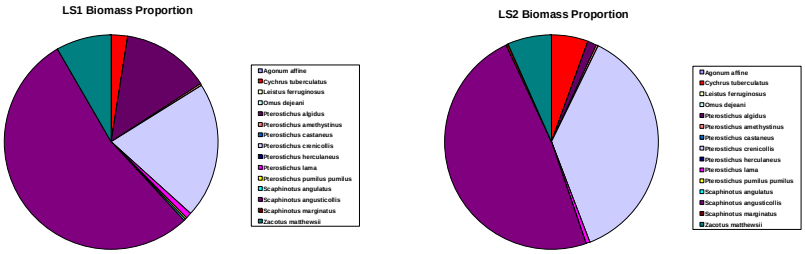
Species Name	K1	K2	K3	LS1	LS2	R1	R2	SL1	SL2
Agonum affine	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.640	0.000
Cychrus tuberculatus	36.064	19.385	45.036	20.833	46.743	20.560	11.749	39.512	54.970
Leistus ferruginosus	0.000	0.000	0.000	0.123	0.184	0.000	0.000	0.000	0.000
Omus dejeani	0.908	0.000	1.412	0.000	0.000	0.000	0.000	0.000	0.000
Pterostichus algidus	0.000	0.000	0.561	**107.808**	11.024	2.694	0.842	2.273	0.000
Pterostichus amethystinus	0.497	0.331	1.546	0.261	1.594	0.927	0.652	1.304	3.439
Pterostichus castaneus	0.303	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pterostichus crenicollis	**625.347**	**545.107**	**447.834**	**166.732**	**309.758**	**202.221**	**194.695**	**210.332**	**127.010**
Pterostichus herculaneus	0.419	0.587	0.000	0.839	0.000	0.587	0.550	0.000	0.000
Pterostichus lama	44.669	42.961	22.782	6.769	6.835	98.126	10.069	28.675	21.582
Pterostichus pumilus pumilus	0.000	0.000	0.000	0.568	0.000	0.927	0.000	0.000	0.000
Scaphinotus angulatus	6.158	8.211	0.000	2.463	0.000	0.000	0.000	3.880	0.000
Scaphinotus angusticollis	**88.816**	1.715	**128.055**	**433.830**	**403.945**	**220.594**	**47.833**	**339.208**	**355.592**
Scaphinotus marginatus	18.276	2.855	16.490	0.424	1.829	1.979	0.495	0.000	0.594
Zacotus matthewsii	0.000	0.000	0.000	66.760	56.801	20.060	5.258	5.096	0.000

Koootowis Biomass Proportions

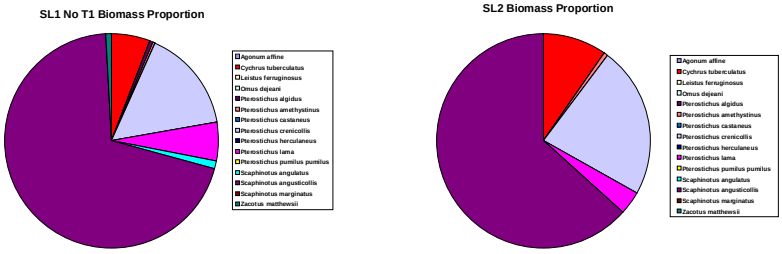




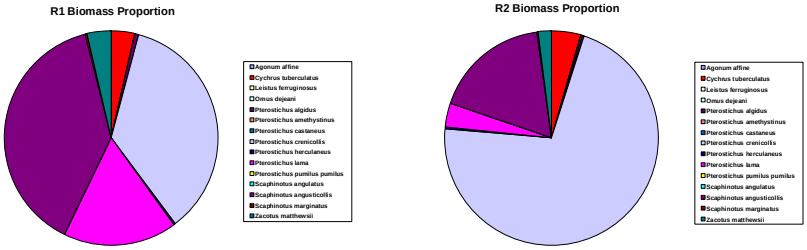
Lost Shoe Biomass Proportions



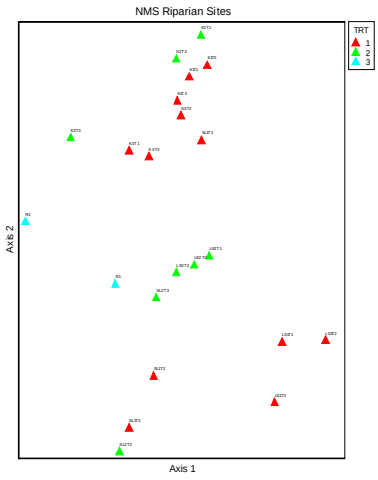
Swan Lake Biomass Proportions



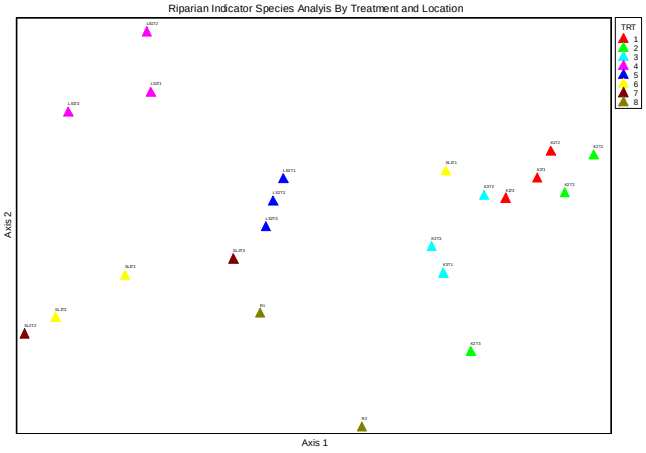
Old Growth Biomass Proportions



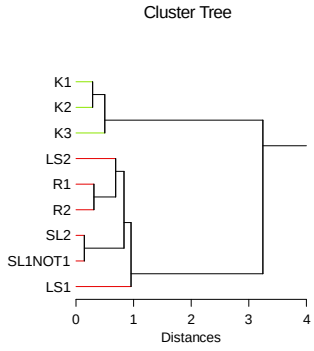
NMS Ordination



NMS Ordination



Cluster Analysis



Objective 2: Examine small mammal and salamander usage of biodiversity features introduced into treated stands

- The wildlife treatments examined in both Swan Lake and Kootowis appeared to be effective for wildlife
- We noted numerous salamanders in the dens at both of these sites, evidence of small mammal den usage, and evidence that carabid beetles, slugs and snails and millipedes use many of the structures
- Addditionally, many of the bycatch species, including snails, grey millipedes (including *Caseya* spp., *Bollmanella* spp., *Taiyutyla* spp. and others), spiders and ants were generally more abundant in the treated sites than in the untreated sites




Objective 3: Compare understory vegetation of treated and untreated buffers, and compare these with old-growth control vegetation

- Vegetation analysis showed that all treated sites showed lower canopy cover, lower shrub cover, higher herb cover and lower moss cover than their associated control sites at each of the three locations, Kootowis, Lost Shoe and Swan Lake

- Treated sites were more similar to old-growth sites in terms of the reduced canopy cover, and high herb cover, but differed in that the former had lower shrub and moss components

Conclusions

- Riparian treatments at the different sites did affect community composition, but the changes to the communities varied from site to site
- *P. crenicollis* declined in all sites
- Old-growth specialist *Zacotus matthewsii* & the forest specialists *S. angusticollis, S. marginatus and S. angulatus* increased in the treated sites over control sites except at Lost Shoe
- Time periods since treatments in these sites varied: restoration treatments at Kootowis done 6-8 years ago; at Swan Lake done 7 years ago; at Lost Shoe done just one year ago
- The immediate response of increased numbers of the generalist *P. algidus* at Lost Shoe may be a short term response to riparian treatments that open up the canopy.
- The wildlife treatments examined in both Swan Lake and Kootowis appeared to be effective for wildlife

Conclusions

- Given the differing objectives of the riparian restoration at each site, and the different time periods since treatment, it appears that objectives aimed to introduce old-growth attributes are relatively successful
- Future monitoring will be vital, to examine how the carabid assemblages change over time in the treated riparian buffers
- Important to pay particular attention to changes in abundance of old-growth specialist, *Zacotus matthewsii;* this species is particularly affected by siliviculture methods & is less resilient than the other species in unsuitable habitat