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# Effect of Stand-Level Structures and Configurations on Carabid Beetles in Coastal B.C. VR sites: Comparison of Riparian retention and Group retention VR Methods.

William Beese, Western Forest Products Inc. & Dr. I.A. Pearsall, Pearsall Ecological Consulting

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## Project Purpose:

The Adaptive Management (AM) program developed by Weyerhaeuser in 1999 is being continued by Western Forest Products Inc. (WFP) following the purchase of the Weyerhaeuser tenure. The aim of this program is to examine the effectiveness of stand-level retention and landscape zoning for maintaining the forest attributes necessary to sustain biodiversity and essential ecosystem functions. Biological processes are difficult to measure directly, but the AM program has identified a range of indicator organisms and structures that might prove useful in assessing ecosystem health. Ideal indicators are individual species or groups of species or structures that perform critical ecosystem functions or are particularly sensitive to the forest attributes disturbed in logging.

Over the past 7 years, we have conducted a number of large-scale field projects to examine the utility of ground beetles as biodiversity indicators (Pearsall, 2002, 2003, 2004, 2005, 2006, 2007). We have identified that carabid beetles are a highly sensitive indicator species with disturbance specialists, generalists, forest and old-growth specialists and with significantly different communities in clearcut, immature and mature forests,. We have shown that their responses are sensitive at small enough spatial and temporal scales such that they may be used to indicate edge conditions and to assess how quickly sites recover and re-establish typical old-growth communities. Through pilot studies, we have been able to fine-tune our methodology to sample effectively using pitfall traps and to give adequate power for appropriate statistical analyses.

In 2007, WFP fully funded our project to evaluate the response of carabids to type and level of retention in one group level (Tsitika) and one dispersed (Stillwater) variable retention adaptive management (VRAM) experimental site 6-years post-harvest. In 2008, with Forest Science Program (FSP) funding, we expanded this study allowing us to make a larger-scale comparison of the effectiveness of other stand-level structures and configurations in maintaining biodiversity in coastal B.C. forests. In 2008 we worked in 3 more of the original VRAM experimental sites that are the foundation of the AM program and will complete this study by working in 2 final VRAM sites in 2009. Over this project we will have worked in group Level, group removal and riparian retention experimental sites as follows: Year 1: Goat Island Group Level, North Island Riparian Retention (Moakwa), Stillwater Riparian Retention (Lewis Lake), Year 2: QCI Group Level, North Island Group Removal.

This study focuses on responses of organisms to stand configurations 4-6 years post-harvest. Information from numerous previous studies will be incorporated into the final analysis, including the data for responses of carabids to type and level of retention in the Tsitika group level and Stillwater dispersed VRAM sites (collected both1 & 6 years' post-harvest), as well as data for responses to group size at two other VRAM sites (Klanawa and Cluxewe/Pt.McNeill). Thus, by the end of this study, we will have information for a total of 9 VRAM sites. VRAM sites were established between 2000 and 2002 and have been installed with random allocation of treatments and controls, with all sites chosen to be as uniform as possible in timber type, site series and topographic features. They make for an ideal experimental platform for analysis of effects of different stand-level configurations on our established indicator species. Upon completion of this study the replication of three large-scale group level VRAM sites will also allow us to develop species abundance response curves for retention levels from 0 to 30%.

**Specific objectives of 2008-9 study:**

The work done during 2008 made up the second year of a 3-year study. The long-term aim of this 3-year study is to identify the stand configurations that allow for greatest retention of carabid diversity as well as to define a response curve by this indicator group to retention type and level, thus assisting forest managers in determining the most appropriate amount and pattern of stand-level retention to conserve biodiversity.

Pitfall trapping was used to examine the epigaeic (ground-dwelling) carabid fauna in three experimental coastal western hemlock stands, two (Goat Island and Lewis Lake) on the mainland of BC, near Powell River, and one at Moakwa, Northern Vancouver Island, between June and September 2008. Moakwa and Lewis Lake are both riparian retention sites, and have similar designs. At both sites, treatments are clearcut, 100%, 50% and 15% retention along streams. At Moakwa, the control site is old-growth, while at Lewis Lake, it is second growth. The Goat Island site, located in the middle of Powell Lake, is a group level retention site and treatments are clearcut, 2$^{nd}$ growth control, 10%, 20% and 30% group retention. All three sites were harvested in 2004.

The main objective of this years' work was to examine the effect of riparian and group level retention cutting methods on carabid populations four years post-harvest. I wished to examine how effective the patches at the Goat Island group level site and the riparian retention sites were at retaining the original carabid community, and to compare this with my findings from 2007 for the Tsitika group level site. I also wished to examine whether there was any evidence of life-boating, and thus whether matrices in the three VRAM sites showed altered communities containing higher proportions of forest specialists than the traditional clearcut treatments at each site. Finally, I wished to compare the two riparian retention sites and determine whether riparian retention blocks contain different communities than patches of trees not anchored on streams.

**Project start date, length of project, and any former project numbers or funding sources:**

This project began April 1 2008 and is a two-year project, ending on March 31 2010. This project is partially funded by WFP and work done in 2007 (making up the first of the 3-year study) was fully funded by WFP. Former project numbers that have linkages with this project include Y072029, Y081156, Y082001, Y083027, Y083030, Y083141 and upcoming project Y102065.

**Methodology overview:**

Pitfall traps have been widely used to sample ground-dwelling arthropods (Southwood 1978), especially carabid beetles (e.g. Waage 1985, Niemela et al. 1990) and was used to capture beetles and other invertebrate species for this project. We have demonstrated (2001-2007) that this method is cost-effective and highly efficient. This is standard methodology for trapping ground-dwelling invertebrates and we follow the guidelines in the Inventory Methods for Terrestrial Arthropods (Resources Inventory Branch 1998).

Carabid beetles were trapped using 15 pitfall traps in the 2$^{nd}$ growth control and clearcut treatments at Goat Island. Sampling design was different in the remaining three group retention treatments at Goat Island, with traps placed within patches (groups of leave trees), at the edge of patches, 5 to 10 m outside of the patches, and in the cut matrix surrounding patches, for a total of 13 traps per patch. Three patches were chosen in the 20% and 30% group level treatments, and just two patches from the 10% treatment, where blowdown was a serious factor, and thus a total of 134 traps were sampled from the site every month.

In the riparian sites, traps were placed along transects running perpendicular to the stream course, starting at the stream edge, and extending through the riparian buffer and a further 75 m into the adjoining cut matrix. 7 traps were placed along 3 transects in each treatment, for a total of 84 traps sampled from each site every month. Traps were set up in all three sites in May and sampled monthly until September.

Carabid beetles were identified to family or genus, and the by-catch was identified only to order. 16 carabid beetle species with a total of 3288 individuals were collected in the Moakwa site, 15 species with a total of 3230 individuals were collected in the Lewis Lake site, and 15 species with a total of 3785 individuals were collected at Goat Island. A total of 10,303 carabids were trapped overall, from a total of 20 species.

**Project scope and regional applicability:**

By the end of the study, we will have made a clear comparison of the effects of dispersed, group level, group removal and riparian group retention as well as group size, as alternative harvesting methods on biodiversity of carabid beetles. We will also be able to define a response curve for abundance of this indicator group with retention type and level, thus assisting managers in determining possible threshold levels suggesting possible ecological minima. Loss of ecological resilience could be apparent when new disturbance specialist species enter and become part of the ecosystem at the expense of the original old growth species, and when recovery of the original community is delayed or negated when patches become incapable of supporting communities of forest specialists. It will be important to assess this over the long term. The utility of this project can be expanded to the landscape level by integration into a full-scale species accounting system.

This study will complement other work that is currently being carried out using carabid beetles as ecological indicators (e.g. work to examine possible associations between carabids and environmental variables such as coarse woody debris, vegetation, stand age and ants by Duncan McColl, UNBC), studies underway at NRC to examine the role of coarse woody debris (CWD) as habitat for epigeic arthropods, as well as other programs under the AM umbrella (effects of VR on planted and natural regeneration, and the use of terrestrial gastropods, epiphytes, and amphibians as indicator species for monitoring biodiversity effects from VR harvesting).

The primary users of our findings will be forest professionals and technicians responsible for managing, developing policies and practices, planning, and designing of forest harvesting in BC Coastal ecosystems. The target audience includes people employed by the BC government, First Nations, forest companies and private consulting firms. Our results will specifically address the design of cutblocks for retention of stand structural attributes to conserve biological diversity. Application of the results to company guidelines and field practices will be facilitated by the AM program (made up of a research and monitoring framework, working groups and a process to provide feedback to management from research findings). WFP is the largest licensee in coastal BC; therefore, results are applied over a large tenure and influence other licensees.

**Interim Results and Conclusions:**

At all three sites, the most abundant species captured was *Scaphinotus angusticollis* (Fischer von Waldheim) and this species was concentrated in the 2$^{nd}$ growth control and 10% patches at Goat Island, within the old-growth control at Moakwa, and within the 50% patches at Lewis Lake. *Zacotus matthewsii*, identified as an old-growth specialist, and *Scaphinotus johnsoni*, an extremely rare species, were both found associated only with the old-growth control site at Moakwa. *Synuchus impunctatus*, identified as a disturbance specialist, was common to most treatments at Goat Island, but was found more commonly in matrix and edge locations at Lewis Lake, Although there were some differences in terms of species composition among the old-growth site at Moakwa and the other two sites, there did not appear to be a particular "riparian" community associated with the riparian retention treatments: indeed, the Moakwa old-growth community clustered more closely with the Goat Island 2nd growth control community than the Lewis Lake riparian 2nd growth control community.

Using non-metric multidimensional scaling, I examined how the sites differed in terms of "species-space". There appeared to be a clear separation of the control and patch communities and the matrix (harvested areas surrounding patches) and clearcut communities when we examined all three sites together. Additionally, edge communities were more similar to control communities, while communities from traps located just 5-10m from the edge of patches had a more similar composition to the matrix communities. Thus, there does appear to be some indication of "typical" interior, edge and matrix communities at these VRAM sites. Indicator species analysis showed that both *Scaphinotus angusticollis* and *Pterostichus neobrunneus* were strong indicator species for patch conditions, as compared to the other species.

Diversity and evenness patterns at Goat Island were similar to those noted in my previous studies: highest diversity and evenness in the clearcut, followed by the 10% treatment, then the 20% treatment, 30% treatment and lowest overall in the 2nd growth control. This same pattern was also true for Lewis Lake and Moakwa: at these sites, evenness and diversity were highest in the clearcut, then the 15% treatment, then the 50% treatment, and lowest overall in the control treatments. This is a result of the dominance of the forest specialist, *S. angusticollis* in control sites, while clearcuts and matrix sites tend to receive an influx of small, winged species that are open-habitat specialists, such as *Harpalus somnulentus, Synuchus impunctatus, Loricera decempunctata, Notiophilus sylvaticus* and *Pterostichus adstrictus* which were rarely caught in the control treatments. When we compare the patterns across the sites, it is apparent that higher diversity is maintained in the control treatments of both of the riparian retention sites over the control treatment at Goat Island, suggesting possibly higher diversity *per se* in riparian sites over sites not anchored on streams.

For Goat Island, although communities from the 10% patches clustered closely with the 2$^{nd}$ growth control, those from the 20% and 30% patches and edges were more similar to the clearcut than the 2$^{nd}$ growth control. Thus, although the 10% patches appear to hold onto the original communities of carabids, this was not the case for the 20% and 30% patches. This is likely a result of the high level of blowdown and disturbance at this site: the 10% patches used were moister, larger and less impacted than the other patches used in the study.

At Lewis Lake, the communities of the 15% and 50% retention sites were more similar to the 2$^{nd}$ growth control than the clearcut treatment at this site: at this site, the 15% treatment was apparently able to retain communities similar to the 2$^{nd}$ growth control, regardless of the location, and did so more effectively than the 50% treatment. Thus, the matrix catches in the 15% location were also similar to the patch catches in that treatment, suggesting that life-boating may have occurred to some extent at this site. Whether this is a result of moderation of temperatures at this site due to the presence of the streams, or the fact that this year was particularly moist, which may have allowed for movement of forest species into cut areas, is unknown. In addition, the 50% retention patch at this site, although large, is located at the top of a steep hill and is at a higher elevation than the other treatments. Meanwhile, abundance of *S. angusticollis* did not vary among the 15% and 50% retention patches and the 100% retention treatment at this site, suggesting that these retention strips were at least effective for retention of this one forest species.

At Moakwa, a different pattern was apparent: the communities in the 15% and 50% treatments clustered more closely with the clearcut community rather than the old-growth control community. This may be a result of the fact that the old-growth specialists such as *Zacotus matthewsii* and *Scaphinotus johnsoni* and the forest specialists *S. angusticollis* and *P. crenicollis*, were found in much greater abundance in the control treatment at this site than in the other treatments. These species may show particularly high fidelity to contiguous patches of forest. At the same time, abundance of *S. angusticollis* was higher in the matrices than the clearcut, suggesting that some lifeboating may be occurring at this site. The differences between Lewis Lake and Moakwa may be the result of the different habitats, climatic variants and age of these two sites.

In summary, group retention patches at Goat Island were generally not effective at retention of the original 2$^{nd}$ growth communities of carabid beetles 4 years post-harvest. However, given that high abundance of forest species were found in the one intact patch in the 10% site, this may be more related to the high levels of disturbance that have occurred at this site due to storms, rather than an inherent property of this VR method. In addition, there did not appear to be effective life-boating at this site. The lack of life-boating was also seen in 2007 at the group level VRAM site at Tsitika. Riparian retention methods did appear effective at preservation of the original communities of forest species at one of the two riparian retention sites sampled, the second growth site at Lewis Lake. At Moakwa, however, the riparian retention strips were not able retain the original old-growth communities effectively, possibly due to the fact that the climax community of the old-growth is made up of species that are not well retained in patches or edges of riparian retention blocks. Some life-boating did occur into matrices surrounding riparian retention blocks.

Future monitoring will be vital, to examine how the carabid assemblages change over time in patches, surrounding matrices, and in the riparian retention blocks. At this time, the direction of carabid species succession is uncertain, since we do not know the possible extent of competitive interactions and whether the size of patches is adequate for long-term survival of beetles at any of the sites.

**Contact information to assist someone in finding additional information on the project:**

For further information, please contact Dr. Isobel A. Pearsall, Pearsall Ecological Consulting, 99 Machleary Street, Nanaimo, B.C. V9R 2G3 pearsalli@shaw.ca

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