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The 6th Eastern Old Growth Forest Conference

Moving Toward Sustainable Forestry: Lessons From Old Growth Forests

September 23-26, 2004
Geneva Point Center, Moultonborough, NH

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September 2004 brought beautiful fall weather and 200 conservationists, land managers, and old growth enthusiasts to the shores of Lake Winnipesauke in Moultonborough NH for the 6th Eastern Old Growth Conference.

The conference was dedicated to furthering the scientific understanding and conservation of old growth forests in the eastern US and Canada and promoting sound forest management, informed by an understanding of old growth forest dynamics. The conference featured scientific research that emerged since the prior conference of 2000 and provided a forum for discussing the identification, protection and use of old growth forests on a working landscape. Specifically, conference objectives were: 1) to disseminate information to conservation groups and the forest products industry about old growth forests; 2) to explore the dynamics of old growth forest ecosystems in a way that can inform sustainable forestry practices; and 3) to provide a forum for discussing the ways in which the land conservation community can partner with the forest products industry in conserving forest lands.

These proceedings were prepared as a supplement to the conference. Papers submitted were not peer reviewed or edited. They were compiled by Karen P. Bennett, Extension Professor and Specialist in Forest Resources. Readers are encouraged to contact authors directly for more information or for clarifications. The papers appear in order of the conference schedule and a table of contents and the concurrent workshop schedule is included as an aid to finding papers of specific interest. Conference organizers are indebted to the authors.

Copies are available on the following website http://ceinfo.unh.edu/Forestry/Forestry.htm or for $5 each from UNH Cooperative Extension, 211 Nesmith Hall, Durham, NH 02824.

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Effects of Old-Growth Riparian Forests on Adirondack Stream Systems

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Introduction

Relationships between riparian forest structure and in-stream aquatic ecosystem habitat characteristics are poorly understood in the northeastern United States. This limits our ability to predict the long-term effects of riparian restoration projects, which often assume increases in riparian functionality as forest stands mature and develop complex structural characteristics. Our research a) describes structural attributes associated with late-successional riparian forests; and b) assesses linkages between these characteristics and indicators of in-stream habitat structure. Key linkages investigated include variations in light availability, coarse woody debris, and associated relationships with in-stream habitat structure (e.g. debris dams and plunge pools). We hypothesize that structurally complex, old-growth riparian forests have strongly associated effects on stream systems, including in-stream habitat conditions that are significantly different from streams surrounded by young to mature forests. Our study focuses on mixed northern hardwood-conifer forests in the Adirondack Mountains of upstate New York. Based on previous research in the Adirondacks (Kraft et al. 2002), it is likely that boulders and stream size also influence variability of in-stream structure. To investigate this, we further explore interactions between forest structure and site-related geomorphic factors.

Methods

Data Collection

Our study was conducted in the southwestern portion of the Adirondack State Park of New York. Study sites were located in three areas: the Adirondack League Club preserve, the Five Ponds wilderness area, and the Pigeon Lakes wilderness area. We sampled a total of 19 sites along 150-300 meter long, 1st and 2nd order stream reaches. Riparian vegetation was dominated by mixed northern hardwood-conifer forests. Sites were classified as mature forest (6 sites), mature with scattered remnant old-growth trees (3 sites), and old-growth (10 sites). At each site, five transects were placed parallel to the stream channel: one along the channel center and two on each side. Side transects were placed inside the forest 5 and 30 m respectively from the channel edge. Leaf area index (LAI) was measured with a Li-Cor 2000 meter at 20-30 randomly selected points along transects. Coarse woody debris volume (CWD) was measured along each transect using a line-intercept method. Hemispheric photos were taken at 3-5 randomly selected intervals along the mid-point of stream channels. Additional metrics of forest structure and composition were inventoried using 8-10 variable radius prism plots randomly nested within the transect grid. Height and crown structure of sampled trees were measured with an Impulse 200 laser rangefinder. In-stream structures, including logs > 30 cm diameter, woody debris dams, boulders > 50 cm width, pools > 10 cm depth, sediment bars, and side channels were mapped using high-precision Global Positioning Systems (GPS). For each structural feature mapped, data was recorded describing dimensions, size, and function (e.g. pool forming element, debris dam anchoring element, bank armoring element, etc.).

Data Analysis

Sample sizes (min 12, max 19) varied by statistical test. In some cases, a reduced set of sites was used if a) CWD had been artificially removed from the stream, b) CWD appeared to have been removed by ice-flows (i.e. at the widest site); or c) data for a specific parameter were not availability from a subset of sites. We used single-factor ANOVA and two-way Tukey comparisons to test for significant differences ($\alpha = 0.05$) in sampled parameters. Equal variance assumptions were confirmed using tests of variance (*F*-tests); *T*-tests assuming unequal variance were used when variance assumptions were not met. Linear regression modeling with alternate curve fitting was used to evaluate relationships between paired continuous variables. We used a log-likelihood ratio, goodness-of-fit (*G* test) to test for significant differences between observed distributions of pool-forming boulders and pool-forming CWD. We used a two-part multivariate analysis to model pool density as a function of multiple predictor variables representing forest structure, in-stream structure, and channel geomorphology. The first part consisted of Classification and Regression Tree (CART) analysis performed using S-Plus statistical software. For the second step we used multiple, linear regression analysis also run in S-plus. We used a single term deletion, forwards and backwards stepwise modeling procedure. Multiple regression modeling provided a useful validation of the CART analysis, because the regressions assessed variability across all sites rather than between partitioned groups of similar sites.

Results

Coarse Woody Debris and Debris Dams

Mean in-stream CWD volumes were significantly ($P < 0.001$) higher at old-growth sites (200 m^3/ha) compared to mature sites (34 m^3/ha) or mature sites with remnant old-growth trees (126 m^3/ha). Volumes were correlated ($R^2 = 0.42$, $P = 0.005$) with the basal area of adjacent riparian forests based on regression results. CWD volumes on the riparian forest floor were significantly higher ($P = 0.001$) at old-growth sites and mature sites with old-growth remnants (159 m^3/ha) than mature sites (86.16 m^3/ha). The volume of CWD within riparian forests was predictive ($R^2 = 0.43$, $P = 0.003$) of CWD recruitment and accumulation in stream channels. In-stream CWD volumes also varied with bankfull width. There was a statistically significant ($R^2 = 0.52$, $P = 0.026$), negative exponential trend of decreasing CWD with increasing bankfull width. CWD volume was positively correlated ($R^2 = 0.48$, $P = 0.013$) with the density of large logs (> 30 cm diameter) as well as debris dams ($R^2 = 0.26$, $P = 0.043$) in stream channels.

Pools

Large log density, rather than CWD volume itself, was predictive of pool density ($R^2 = 0.32$, $P = 0.046$). A logarithmic curve explained the most variability in this relationship. Pool density (log transformed) declines significantly ($R^2 = 0.43$, $P = 0.022$) with increasing bankfull width at our sites. There was a significantly higher proportion of CWD-formed pools relative to boulder-formed pools at old-growth sites as compared to mature sites ($P < 0.001$). Along old-growth stream reaches, 49 and 40% of pools were formed by CWD and boulders respectively, with the remainder not attributable to a specific pool-forming element. The proportions were reversed at mature sites: CWD formed 20%, boulders formed 58%, and the remaining pools were unrelated to either.

Multivariate analyses supported our hypothesis of an interaction between riparian forest structure and site-specific geomorphology. CART analysis identified the strongest predictors of pool density from a set of predictor variables that included forest age class, basal area, large log density, stream bankfull width, and boulder density. Of these, log density, bankfull width, and boulder density, in decreasing order of significance, were the strongest predictors of values of the dependent variable (pool density). Multiple regression analysis produced a final model that was consistent with the CART results. However, the regression model, selected from the same initial set of predictor variables, included only log density and bankfull width. This suggests that these two variables explain the most variation in pool density when assessed across all sites. The model was statistically significant ($P = 0.024$), explaining 56% of variation in pool density.

Light Availability

We used Leaf Area Index (LAI) as an indicator of multiple aspects of vertical forest structure, including light availability. LAI over stream channels showed a strong negative relationship with bankfull width ($R^2 = 0.62$, $P = 0.004$), with decreasing overhead foliage as streams widened. LAI values decreased most precipitously for streams wider than 6 m bankfull width. When our analysis was restricted to streams < 6 m wide, mean LAI over stream channels was not significantly greater ($P = 0.084$) for old-growth (4.9) than for mature stands (3.7) or mature stands with remnants (3.6). There was no significant difference ($P = 0.239$) between age classes for LAI within adjacent riparian forests either. However, the standard deviation of LAI was significantly greater ($P = 0.049$) along old-growth stream channels compared to younger sites. This indicates that LAI is more spatially variable over old-growth stream channels. Visual inspection of hemispheric photographs supported our interpretation of patchy canopy structure over old-growth streams; a more homogeneous, closed canopy was characteristic of our mature riparian sites.

Discussion

Old-growth riparian forests in the Adirondacks strongly affect in-stream habitat characteristics, including CWD availability, pool density, and the light environment. Basal area is positively correlated with stand age in Adirondack northern hardwood-conifer forests based on our research and previous studies (Woods and Cogbill 1994, Ziegler 2000). At our sites, higher basal areas generate greater accumulations of downed coarse woody debris, both within the riparian forest and in the stream channel. CWD volume positively correlates with the density of large logs and debris dams. Pools form above and below these structures. Consequently, pool density is higher in old-growth reaches. This research corroborates work done in the Pacific Northwest by Montgomery et al. (1995) who found that high LWD abundance in those streams can significantly increase pool frequency. Increased pool densities provide habitats for a range of aquatic biota (Wallace et al. 1995, Gowan and Fausch 1996, Roni and Quinn 2001). LWD provides a variety of other ecological and abiotic functions in stream ecosystems, including retention of sediment and organic material, which can have significant implications for stream nutrient cycling (Valette et al. 2002, Brinson and Verhoeven 1999).

The average volume of CWD in old-growth channels (199 m^3/ha) was substantially higher than previously reported for upland old-growth northern hardwoods in the Adirondacks by Ziegler (2000) (139 m^3/ha) and McGee et al. (1999) (126 m^3/ha). It is possible that CWD accumulations in old-growth streams are higher than in upland forests due to a) disturbances (e.g. flooding and bank under-cutting) along forest-stream edges (Gregory et al. 1991) and b) decreased decomposition rates for fully submerged logs. CWD accumulations (“debris dams”) have a number of additional effects on aquatic ecosystems, which also include retention of organic matter for detritus-dependent biota (Bilby and Likens 1980) and dissipation of energy during flood events (Naiman et al. 1998).

Spatial variability in LAI was much higher over old-growth channels. This explains the complex light environment we observed at old-growth sites and apparent in hemispheric photographs. Light variability is related to the high frequency of canopy gaps typically found in old-growth northern hardwoods (Dahir and Lorimer 1996). As a consequence, streams move in and out of shaded and sunlit areas. This contrasts with mature forest reaches, where overhead canopies are closed and more spatially homogeneous. In-stream productivity in closed canopy riparian systems is likely to remain predominately heterotrophic (Naiman et al. 1998). We hypothesize, while not tested in this investigation, that a heterogeneous light environment present in many old-growth canopies may increase primary productivity in endogenous streams while also maintaining high allochthonous inputs and cool, shaded conditions preferred by many headwater biota.

Our findings have a number of implications for restoration and watershed management. First, restorationists should consider promoting late-successional/old-growth forest conditions where the associated in-stream habitat characteristics are desired. Second, watershed managers can use riparian forest structure as an indicator of present and future potential riparian functionality. Because riparian old-growth forests can provide high-quality stream habitats, riparian buffer systems could be designed to incorporate protected old-growth riparian corridors if possible. Where old-growth riparian forests are not currently available, mature riparian forests offer a source for future old-growth structure, provided forest management practices are employed that either maintain or enhance, rather than retard, stand development potential (Keeton 2004).

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