Riparian Management Zone width and its influence on stream characteristics following forest clearcutting: A case study of small streams in Japan*  

Kaori Itoh¹, Francis Greulich², Edwin S. Miyata³, Takuyuki Yoshioka³, Koki Inoue⁴ and Itsuro Ishigaki⁵  
¹Visiting Scientist and ²Professors, College of Forest Resources, University of Washington, Seattle, WA  
³Research Assistant, ⁴Professor and ⁵Assistant Professor, College of Bioresource Sciences, Nihon University, Japan  
Email: waruinekotanme@hotmail.com  

ABSTRACT: Unlike Washington State, Japan does not currently have timber harvesting regulations specifically applicable to riparian zones. If however, Riparian Management Zones (RMZs) were to be established in Japan and subsequent timber harvesting in these zones heavily restricted, the forest-based economy in Japan may worsen. In order to conserve an acceptable stream environment, as well as an economically viable forest industry, it is essential to examine the tradeoffs. These tradeoffs involve buffer strip width, an important component of RMZ design and management. The purpose of this study was to quantify the impact of undisturbed RMZ width as well as allowable length of clearcut area along the stream on: solar radiation, water temperature, algae biomass, and aquatic insect population levels. Measurements of these factors were taken at 200 meter intervals along the streams examined in this study. Stream A is located in an undisturbed forested watershed. An otherwise comparable stream B flows through a clearcut but is protected by a riparian buffer zone of 25 meters. Similar measurements were taken along three other streams. Stream C is also located within an undisturbed forest area, while stream D flows through a clearcut without benefit of a riparian buffer zone and stream E flows through a planting without benefit of a riparian buffer zone. A comparative analysis of streams A and B suggest that a RMZ of more than 25 meters in width might be desirable for reducing the environmental impact of clearcutting to an acceptable level. Contrarily, an analysis of streams C, D, and E supports an argument for felling areas within the RMZ of less than 25 meters and for planted areas within the RMZ of less than 75 meters. This study was supported in part by the fellowship of the Japan Forest Technology Association and by the Tanzawa Ooyama Synthetic Investigation in Kanagawa Prefecture, Japan.  

Keywords: riparian management zone width, clearcutting, water temperature, aquatic insect, algae  

1. INTRODUCTION  

The riparian forest has several functions and among these are: interception of solar radiation, moderation of water temperature, provision of organic matter, and control of erosion (Nakamura 1995). The riparian forest thereby conserves physical properties of the stream and its biodiversity. In Washington State the establishment of Riparian Management Zones (RMZs) is one of the antecedents to active management of the riparian forest. This management includes banning
clearcuts within a "Core Zone". It also regulates clearcutting beyond the Core Zone but within an "Outer Zone" (Department of Natural Resources. 1997). Hence RMZ management decreases the influence of clearcutting around streams and maintains a habitat suitable for fish and the other organisms, both terrestrial and aquatic.

Unlike Washington State, Japan does not currently have timber harvesting regulations specifically applicable to riparian zones. If however, RMZs were to be established in Japan and subsequent timber harvesting in these zones heavily restricted, the forest-based economy in Japan may worsen.

In order to conserve an acceptable stream environment, as well as an economically viable forest industry, it is essential to examine the tradeoffs. These tradeoffs involve buffer strip width, an important component of RMZ design and management.

1.1 Objectives

The objective of this study was to compare, in a quantitative fashion, the impact of undisturbed riparian zone forest width and clearcutting on: solar radiation, water temperature, algae populations, and insect populations. In order to quantify these impacts, two investigative activities were conducted.

Research Activity 1. The quantification of RMZ impact comparing two streams; stream A, which is undisturbed, and stream B, flowing through an area which was clearcut except for a RMZ width of 25 meters on one side.

Research Activity 2: The quantification of the impact of clearcutting within the RMZ along three streams: an undisturbed stream C, a stream D along which the RMZ was removed by clearcutting on the left side, and a stream E, along which the forest was clearcut and replanted on both sides.

1.2 RMZ Width and Clearcut Removals within the RMZ

Figures 1 and 2 show the RMZ width and the permitted clearcut length in the RMZ. The RMZ width is measured perpendicularly from the stream edge on one side. This RMZ forest is expected to exert several positive impacts on stream properties as well as to decrease some of the negative impacts of felling on forest habitat. Allowable clearcutting along the stream edge comprises two distances, the entire length along one side of the stream and a specified length on the other side of the stream. The clearcut width within the RMZ is limited to the height of adjacent trees. This height ensures that the water surface will receive solar radiation leading to increased populations of algae and aquatic insects. At the same time, the limitation of clearcut area length along the stream may effectively restrict a detrimental rise in water temperature. Through setting RMZ width and permissible clearcutting lengths within the RMZ, it may be possible to maintain timber harvesting at acceptable levels while reducing the impacts of felling on the stream environment.
2. METHODS

Factors measured included, under-crown solar radiation, water temperature, and population levels for algae and insects. Measurement procedures and locations were as follows.

**Under-crown solar radiation:** Under-crown solar radiation was measured at one minute intervals by a solar radiation recorder MDS/MkV/L (http://www.alec-electronics.co.jp). The sensor was set at a height of 1.5 meters and under the crown of a riparian tree near the stream. One measurement point was located along each of streams A, B, C, and E. On stream D 2 measurement points were taken, one within the forest area and a second in the clearcut area.

**Water temperature:** Water temperature was measured at hourly intervals by a Thermo Recorder Mini RT-30S (http://www.especmic.co.jp/). The sensor was set at 4 points with a 200m interval in streams A and B. In steams D and E, it was set at a 25m interval. Stream D had 8 recording points and stream E had 9 points. On stream C, it was set at 3 points with a 50m interval.

**Algae biomass and aquatic insect level:** The algae population level was measured as the dry algae weight on a 5cm (25cm²) square placed on the surface of a stream rock (Aruga, *et al.* 2000). The aquatic insect population level was measured as a numerical count by genera, and species where possible, taken under stream rocks using a quadrat sample square of 25cm (625cm²). These population measurement points were placed between measurement points for water temperature, and three samples were taken at each point.

2.1 Study Sites

**Research Activity 1. RMZ width:** In order to quantify the impact of RMZ width, research was done at two stream sites, A and B. Site A was an undisturbed stream, and site B was in a clearcut and planted area with a RMZ of 25 meters. These streams are tributaries of the Oomatasawa River in Kanagawa prefecture in Japan. Stream A’s catchment area is 30.8 hectares and is 86% covered with Hinoki Cypress (*Chamaecyparis obtusa*). Stream B’s catchment area is 69.9 hectares and is 68 % covered with Hinoki Cypress. The upper reaches of stream B, have 1.9 hectares planted to trees of 5 or 6 years. The lower reaches are located in a 1.4 hectare clearcut.

**Research Activity 2. Allowable clearcutting length at RMZ:** In order to quantify the impact of clearcutting length within the RMZ, the following three streams were investigated. Stream C is located in an undisturbed watershed. Stream D is without a RMZ and has a clearcut and planted area at its left side. Stream E, without a RMZ, flows through an area planted with trees
of one or two years along both stream sides. These streams are tributaries of the Tenryu river in Shizuoka prefecture. Stream C’s catchment area is 4.2 hectare and is forested with Hinoki cypress and Sugi pine (*Cryptomeria japonica*). Stream D’s catchment area is 17.9 hectare forested with mainly Hinoki cypress and Japanese red pine (*Pinus densiflora*). Within this catchment there is also a 1.2 hectare clearcut and a 0.2 hectare planted area. Length of the clearcut area along stream D is 100 meters. Stream E’s catchment area is 6.0 hectares and is forested with Hinoki Cypress and Sugi pine. This catchment also has 1.7 hectares of one or two year old trees. Length of the planted area along stream E is 125 meters.

3. RESULTS

3.1 Research Activity 1. RMZ width

**Under-crown solar radiation:** Figure 3 shows total daily global solar radiation and the corresponding under-crown radiation. Total daily global solar radiation tended to decrease from October 2004 to December 2004 while under-crown solar radiation during this same period had an increasing trend. The putative reason is that both of these streams flow through deciduous broad-leafed forests which are losing their leaves during this period. The under-crown solar radiation of stream B was more than that of stream A during this period. However, in the month of October, during which the leaves of stream A and B’s riparian forest didn’t fall completely, the under-crown solar radiation of stream B was equal that of A. These data suggest that a RMZ of 25 meters intercepted solar radiation as well as the undisturbed forest cover of stream A.

![Figure 3](image)

**Daily maximum water temperature and diurnal range of water temperature:** Figures 4A and 4B show daily maximum water temperatures and the diurnal ranges of water temperature for both streams from August 2004 through December 2004. August water temperatures tend to be the warmest observed during this period in both streams A and B. It is observed from the charts however that the water temperature rise between points 1 and 4 for both streams was not the highest during August. It was expected that the water temperature rise of stream B between points 1 and 4, where it flows through a clearcut, would be particularly noticeable. Unexpectedly, this increased temperature was not observed. It is inferred from this comparative analysis of water temperatures in streams A and B that a RMZ of 25 meters along stream B moderated the rise of its water temperature.
Algae biomass: Figure 5 shows algae biomass measured at various points along streams A and B. In stream A the biomass measured at the 3 points was essentially the same. For stream B, algae biomass in the planted and clearcut areas were both less than that found in the forested zone. Factors that have been identified as tending to decrease algae biomass are: decreasing solar radiation, increasing stream velocity and discharge levels, and increasing suspended sediment (Akimoto et al. 1986). Increased sediment loads were undoubtedly put into stream B from the clearcutting done 5 or 6 years prior to this study. It is hypothesized that the algae biomass decline observed in the planted and clearcut areas is due to this increased sediment load as well as increased stream velocity and discharge.

Aquatic insects: Figure 6 shows the number of species of aquatic insects at each sampling point of streams A and B as well as the total population count. Stream A had no significant difference in population count and number of species at the 3 sampling points. On stream B there was a decline in both species and total population count moving from forest, to planted area, to clearcut. Factors that tend to decrease aquatic insect population levels and diversity are increasing stream velocity and discharge and increasing sediment load. The sediment load is particularly important as it covers interstitial space between stones in the stream bed (Takemon 1998). Reduced habitat availability and quality negatively impact the aquatic insect biota. A comparison of the planted and clearcut areas shows that the negative impact was greater in the clearcut, both in terms of total population and number of species. Hence, it is hypothesized that
immediate replanting after a clearcutting operation has the potential to reduce sediment loads after harvest. Consequently it is proposed that a RMZ of more than 25 meters in width is needed or immediate replanting should occur. These remedies might be judged suitable for reducing the environmental impact of clearcutting to an acceptable level based on stream B observations.

**Discussion:** Data of under-crown solar radiation and water temperature shows that a RMZ width of 25 meters effectively moderates solar radiation and water temperature. From this perspective it appears that a RMZ width of 25 meters effectively buffers these effects associated with clearcutting. On the other hand, algae biomass and aquatic insect population numbers and species all tend to decrease in both planted and clearcut areas. The impact on aquatic insects was particularly significant. It was not possible however to conclude that decreasing levels of algae and aquatic insect populations were due to clearcutting. It is necessary to investigate in more detail the origin of the suspended sediment in order to determine what percentage comes from the upper stream, the clearcut and the planted area.

### 3.2 Research Activity 2. Allowable clearcutting length in the RMZ

**Under-crown solar radiation and solar radiation at clearcut area:** Figure 7 shows under-crown solar radiation and solar radiation in the clearcut area from July through December. Under-crown solar radiation within the forest area of streams C, D, and E ranged between 50 w/m²/day and 600 w/m²/day during this period. Solar radiation in the clearcut area ranged between 660 w/m²/day and 2500 w/m²/day. These data show that solar radiation reaching the water surface in the clearcut area is 12 times higher than that within the forest area of stream D.
Daily maximum water temperature and the diurnal range in water temperature:

Figure 8 shows daily maximum water temperature and diurnal range of the water temperature from July through December. A major determinant of allowable clearcutting length in the RMZ is its impact on daily maximum water temperature. This temperature reaches its maximum between July and August. There is a relationship between stream water temperature and feeding activity of Yamame (Oncorhynchus masou), a Salmonid. Feeding activity of Yamame occurs when the water temperature is between 18 and 22°C. Water temperatures between 24 and 26°C place it in a feeding stasis, and over 26°C feeding is entirely halted (Sato et al. 2001).

Daily maximum water temperatures in stream C ranged between 20.1 and 21.4°C, meaning that stream C was cool enough to keep feeding activity brisk. In stream D however, daily maximum water temperature rose to 24.8°C when it flowed through a clearcut area of only 25 meters, which would place Yamame in a state of feeding stasis. In stream E, daily maximum water temperature rose to 24.2°C when it flowed through a planted area of 75 meters, which also implies a feeding stasis. An analysis of streams C, D, and E supports an argument for keeping the clearcut area within the RMZ to less than 25 meters in stream D, and an argument for keeping the planted area within the RMZ to less than 75 meters in stream E.
Algae biomass: Figure 9 shows the average algae biomass of streams C, D, and E. Figure 10 shows algae biomass at each measurement point in streams C, D, and E. Comparing average algae biomass, it is noted that streams D and E have higher levels than C. It was therefore presumed that RMZ conditions that include clearcuts and planted areas increased algae biomass. Algae biomass of the clearcut area were more than that of the forest area of stream D. If there are clearcut areas in upper stream reaches the algae biomass of lower forested areas is higher than the upper forested area. These data support the hypothesis that stream environments with a lot of solar radiation, such as that provided by clearcuts, tend to have higher algae biomass.
Aquatic insects: Figure 11 shows the total population size and number of species of aquatic insects of stream C, D, and E. Figure 12 shows these measurements at different points along streams C, D, and E. The population size was highest in stream E, and the number of species was highest in stream C.
Upon comparison of the various measurement points, it is noted that both population size and number of species tend to increase with planted and clearcut area. This observation supports the idea that RMZs with clearcut and planted areas have both larger populations and higher diversity of aquatic insects. In stream D the clearcut area in the RMZ tends to increase the population of aquatic insects during ordinary water discharge. In the case of heavy rainfall however, there is some fear that the population size and diversity of aquatic insects will decrease as a consequence of sediment flow from the clearcut area into the stream.

Discussion: A comparison of solar radiation reaching the water surface within the clearcut area of stream D and that of a forested area shows 12 times more radiation within the clearcut. The allowable clearcutting length within the RMZ were quantified by examining the relationship between daily maximum water temperatures in streams C, D, and E with the feeding activity of Yamame. As a result of this examination it is suggested that clearcut areas within the RMZ should be less than 25 meters and planted areas less than 75 meters. These limits on clearcut and planted areas should maintain stream water temperatures which encourage feeding activity. These limits will also create a stream environment that promotes healthy levels of algae biomass and aquatic insect populations.

4. CONCLUSION

This study quantified the impact of undisturbed RMZ width as well as allowable clearcutting length in the RMZ. The undisturbed stream environment was evaluated and compared with the influence of clearcutting on physical and organic factors. This is an important step toward developing and evaluating a RMZ tradeoff model that varies buffer width and harvesting intensity with different levels of water resource protection.

5. REFERENCES CITED

Department of Natural Resources. 1997. Forest Practices Illustrated. 63pp