INITIATION OF LONG-TERM, STAND-LEVEL MONITORING OF VEGETATION IN AQUARIUS RESEARCH NATURAL AREA, CLEARWATER NATIONAL FOREST

by

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Abstract

Landscape-level vegetation monitoring presents many challenges. However, the most rapid changes in vegetation often occur at this scale. In this project, baseline data were collected from plant communities in Aquarius Research Natural Area (RNA), to provide a basis for vegetation monitoring at a landscape scale. In order to sample and describe the range of plant communities making up the RNA, a gradient-transect approach was implemented, which attempts to maximize the environmental gradient sampled. The Forest Service's Timber stand management record system (TSMRS) was used to determine the different combinations of landform, parent material, and aspect present in the RNA and to estimate the number of acres within each combination (bioenvironment). Each bioenvironment was then sampled relative to its representation in the study area. Tenth-acre plots were used to sample canopy cover by species within three canopy layers, and a variable-plot method was used to estimate tree density. In addition, permanent plots were established within a recent burn and a windthrow area, representing important disturbance types in the RNA. Obtaining a representative sample of the bioenvironments as defined *apriori* proved difficult and used resources that may have been better spent on more thorough stand descriptions. However, the design resulted in a thorough inventory of habitat types in the RNA, their relationship to bioenvironments, and their present condition. Data were used to classify stands as to seral status and structural condition. Six stands were selected that represent the range in seral stages and structural conditions present, and can serve as locations for more detailed monitoring. Plot locations, mapped at 1:24,000, can serve as training areas for interpreting aerial photos of the RNA and tracking changes in the pattern of plant communities.

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Introduction

Long-term ecological monitoring of plant communities is identified as a priority in the *Implementation Plan for Management and Monitoring* for Aquarius RNA (Lichthardt 1995). The purpose of long-term ecological monitoring, or baseline monitoring, is to document the rates and types of changes that occur in response to natural processes such as succession and disturbance (Elzinga and Evenden 1994). Two recent, extensive disturbances in Aquarius Research Natural Area (RNA) illustrate the need for broad-scale baseline data and a method of documenting changes in landscape patterns over time.

Justification for establishment of Aquarius RNA was primarily related to the occurrence of rare and disjunct plant species and rare plant associations. Permanent monitoring plots have been established in eleven examples of plant associations of interest including western redcedar/maidenhair fern (*Thuja plicata/Adiantum pedatum*), western redcedar/woodfern *(Thuja plicata/Dryopteris* spp.), and red alder/maidenhair fern *(Alnus rubra/Adiantum pedatum*); as well as in five populations of rare plants (Lichthardt 1992). Monitoring plots are all located in forest communities in late-seral or climax stages of development.

The scope of current monitoring is not indicative of the diversity of plant communities present in the RNA, or even of the major forest communities. Knowledge of structural condition and seral status of forest communities is important for understanding and documenting the contribution of a site to conservation. Stand structure and seral status also determine ecosystem processes such as: provision of habitat for plant and animal species, fire behavior, disease behavior, and the interactions between these factors.

In this project, I sought to sample and describe the structure and seral status of plant communities present within major habitat types represented in the RNA. The resultant data can be used to more accurately define the plant communities associated with stand polygons that have been delineated in the RNA. This map of plant communities can then be used, in conjunction with aerial photography, to monitor broad-scale changes over time.

Objectives

Objectives of this project were:

- To quantitatively describe the range of plant communities occurring along major environmental gradients within the RNA.

- To document the structure and species composition of specific stands that can be used as training points for interpreting aerial photos of the RNA, with the ultimate objective of tracking changes in vegetation patterns in the RNA over time.

- To establish permanent plots in recent disturbance patches that can be used to detect site-specific changes in vegetation following disturbance.

Study Area

The 3900-acre (1578-ha) RNA lies almost entirely within breaklands of the North Fork Clearwater River. Slopes rise steeply from the river on either side of the westerly flowing river section. Slopes are extremely steep except for areas of undulating, mass-wasted slopes resulting from the inherent instability of the schist parent material.

Within the RNA is preserved a portion of the core area of coastal refugium in the Northern Rockies (Lichthardt and Moseley 1994). River elevations of 1500 ft (460 m), are entrenched within the mountainous western edge of the Clearwater Mountains creating uniquely wet, mild conditions which are reflected in the occurrence of unique community types and large degree of floristic affinity with Pacific coastal forests.

Most of the RNA is densely forested. Habitat types are predominantly those of the western redcedar series. However, the existing forest cover is a mosaic of stand ages and species composition reflecting primarily aspect (north vs. south-facing canyonsides) and past fire history (Barrett 1993). Stand-replacing wildfires affected extensive areas of the RNA in 1910 and 1931, but many stands date from earlier fires (1836 to 1868; Table 6). Fires on the moist slopes south of the river, and lower slopes on the north side, tended to underburn as indicated by fire scars on large individuals of western redcedar. Where stand-replacing fires occurred, charred cedar shells usually provide evidence of the climax vegetation type. Douglas-fir is the dominant seral species after fire, although grand fir is frequently co-dominant. White pine blister rust reached the area in the early 1900s, and the die-off of white pine opened the canopy of some stands, significantly affecting their structure.

There are inclusions of steep rock outcrop on the north side of the river on which shrubland is probably the potential natural vegetation. In the spring, moist rock faces on both sides of the river are moss-covered and support a diversity of wet-site forbs not found in the forest understory.

Appendix A, Map 1 shows the delineation of landtypes in the RNA as taken from 1:24,000 maps obtained from the Clearwater National Forest Supervisor's office. Landtypes are fully described in Wilson *et al.* (1983). Much of the RNA consists of landtype 50–mass-wasted slopes. This landtype is typical of schist parent material. The remainder is mostly in landtypes 60S and 61S, steeply sloping stream breaklands in mica schist. Stream breaklands also include granitic (60G) and undifferentiated (61U) parent materials. A minor portion of the area at upper elevations is classified as moderate relief uplands and mountain slopelands (landtypes 24S and 31S). In contrast to stream breaklands, these have slopes generally less than 60% and do not adjoin actively downcutting streams. The parent material is mica schist.

This study did not target river terraces (landtype 10A) which were sampled by Lichthardt (1991) and Lichthardt and Moseley (1994), or riparian stringers. These landforms are not sufficiently delineated at the scale used in this project.

Thorough descriptions of the environment and vegetation of Aquarius RNA can be found in Moseley and Wellner (1988). A description of the Clearwater refugium environment and its biodiversity values can be found in Lichthardt and Moseley (1994).

Methods

To describe the range of seral and structural conditions represented in the RNA, an objective sampling design was imposed similar to the gradient transect method described by Austin and Heyligers (1989) and used in a larger study of the Clearwater refugium (Lichthardt and Moseley 1994). This method is designed to capture the environmental variation present in the study area and therefore maximize the biological diversity sampled. It requires stratification of the study area, based on significant environmental variables which have been previously delineated. The RNA was stratified for sampling based on elevation, as an indicator of temperature; aspect, as an indicator of moisture regime; and landtype, as an indicator of landform and parent material. Canyonside (north vs. south) was further used as a proxy for aspect.

Elevation zones (2,000-2,400 ft and 2,400-4,000 ft) were designed to partition the unsampled area of the RNA approximately in half, and to spread samples across the elevational gradient present. Elevations of 1,600 to 2,000 ft are represented in earlier sampling (Lichthardt 1991; Lichthardt and Moseley 1994). Since the North Fork Clearwater River through Aquarius trends east-west and the slopes on either side are very steep, aspects on the north side are generally warm and those on the south, cool. Therefore for convenience, the area was stratified into south and north canyonsides, ignoring inclusions of cool aspects on the north side and visa versa. Nine described landtypes (Wilson *et al.* 1983) are mapped in the RNA (Table 1). Landtypes are a combination of landform and parent material.

Table 1. Landtypes mapped in Aquarius RNA (Wilson *et al.* 1983).

Map code	Landform	Parent material
10A	Flood plains, terraces	Alluvium
15U	Colluvial toeslopes and fans	Undifferentiated
24S	Moderate relief uplands	Mica schist
31S	Mountain slopelands	Mica schist
50	Mass-wasted slopes	Various
60G	Non-dissected stream breaklands	Granitics
60S	Non-dissected stream breaklands	Mica schist
61S	Dissected stream breaklands	Mica schist
61U	Dissected stream breaklands	Undifferentiated

A map of bioenvironments (canyonside x elevation zone x landtype combinations) was created by overlaying the landtype map onto a 7.5’ topo quad with the 2,000-ft and 2,400-ft contour intervals, and RNA boundaries delineated (Appendix A, Map 1). Acreage within each bioenvironment was determined by overlaying this map on 8 squares/inch graph paper and counting the number of points (meeting points of grid squares) within each polygon.

The number of acres per grid point was determined by dividing the total acreage of the RNA (3390 acres) by the total number of grid points. Using this method, I arrived at a conversion factor of 0.745 acres/grid point. Acreage by bioenvironment is shown in Table 2.

The RNA has been delineated into stand polygons, which reflect vegetative cover types as identified from aerial photographs. Stands are numbered in a hierarchical system, by compartment, subcompartment, and stand. Appendix A, Map 3 shows numbered stands with subcompartment numbers circled. The area north of the river is in compartment 302 and most of the area to the south, compartment 303. South of the river, the easternmost portion of the RNA, in range 7-east, is in compartment 313.

Stand polygons formed the basis of sampling. For example, to represent a bioenvironment cell that was landtype 50, north side of the river, between 2,000 and 2,400 ft, I looked for the most easily accessible stands representing that landtype, that overlapped that elevation zone. My goal was to place only one plot in a stand, in this way spreading the samples across different seral and structural types in each bioenvironment.

Table 2. Acreage by bioenvironment (canyonside x elevation zone x landtype).

Canyonside	Elev. zone	Landtype	Acres	Acres as % of total
	ft			%
North side (Warm aspects)	1600-2000	15U	35	1.0
		31S	21	0.6
		50	80	2.4
		61U	63	1.8
	2000-2400	31S	20	0.6
		50	160	4.7
		61U	50	1.5
	> 2400	31S	97	2.9
		50	168	5.0
		60S	115	3.4
		61S	283	8.3
		61U	33	1.0
South side (Cool aspects)	1600-2000	10A	18	0.5
		31S	46	1.4
		50	404	11.9
		60G	47	1.4
	2000-2400	31S	62	1.8
		50	510	15.0
		60G	39	1.2
		60S	36	1.1
		61S	15	0.4
	> 2400	Rock	16	0.5
		24S	44	1.3
		31S	43	1.3
		50	542	16.0
		60G	15	0.4
		60S	389	11.5
		61S	39	1.1
	Totals		3390	100

A single, tenth-acre plot was subjectively placed to represent the character of a stand. The plot was a circle of 37-ft radius. The plot was placed in a relatively homogeneous area when possible, or within one cover type that was part of a mosaic making up the stand. Structure and composition of the overstory were the primary criteria.

Ecodata methods (Bourgeron *et al*. 1991) were used to record vegetation and site data. Because Ecodata plots have been used in and near the RNA in previous years, I began numbering plots with the next, consecutive 3-digit number not used in previous plots: 063. This will avoid confusion in the event that all plots in the RNA are summarized, and eliminates the need to prefix the plot number with the year and recorder's initials, as is the system with Ecodata key i.d. numbers.

Canopy cover was recorded by species and by life form within three strata: under 2.5 ft, 2.5 to 6.5 ft, and over 6.5 ft . Tree cover was recorded by diameter class and by species within diameter class. From plot center, a relascope, with basal area factor 20, was used to determine which trees fell within a variable plot, then each tree counted "in" was measured for dbh to give an estimate of trees/acre using the following formula:

$$\text{Trees per acre} = \sum \frac{\text{BAF } (183.35)}{d^2}$$

where BAF = 20, and d = diameter at breast height in inches.

Saplings are too small to be counted with this method, so a simple count of saplings was made within the 0.1-acre plot.

Whenever possible, one or more trees from the dominant size class was bored as an indication of the age of the stand. Western redcedar were generally avoided because of their hollow centers. Height was measured on an individual in the canopy layer with the greatest foliar volume to indicate dominant layer height.

At least one photo was taken of each plot. A complete set of slide transparencies and Ecodata field forms are on file at: the Natural Areas Program, USDA Forest Service, Rocky Mountain Research Station, Missoula, Montana; and at the Idaho Department of Fish and Game, Conservation Data Center (CDC) in Boise.

Permanent plots were established at two places to monitor disturbance patches: #64 is within the 1994 Sam burn, and #86 is in an opening created by a major blowdown event, also in 1994. Permanent plots are marked at the center with steel fence posts, and the tops are inscribed with the plot number.

The Sam fire started on August 3rd of 1994 and was primarily a surface fire which crowned out in several places creating openings of 3 acres or less. Many small-diameter understory trees, primarily grand fir and western redcedar, were killed. The plot is accessed from the 6042 road east of Swan Point. At the end of the road, a broad ridge runs from the road into section 36 and there is only a narrow strip of unburned forest between the road and the burn. The plot is just off the eastern side of this ridge, between the ridge and some very steep slopes.

The blowdown area northeast of Thompson Point is a 30-acre swath in which most of the trees, primarily Douglas-fir, red alder, and western larch, were broken off in a single wind event in May of 1994. Only scattered, mostly small-diameter, trees remain standing. The blowdown is delineated as stand number 303-3-50 in Appendix A, Map 3. Plot 86 is located near the top of the swath, close to its eastern edge. The very top of the blowdown narrows abruptly and has a gentle slope. The plot is just below a break in the slope where it becomes slightly steeper, on an aspect of 70°. A small stream runs along the eastern edge of the plot. There are six recent tip-up mounds in the plot, and also a large, natural debris pile in the west half. The plot is marked at the center with a steel center post painted yellow.

Results

Access to the RNA south of the river is extremely difficult, and the sampling design did not mitigate travel problems as much as was hoped, primarily because extensive areas of landtype 50 are located south of the river, in the most remote area of the RNA.

Thirty-three plots were ultimately sampled, representing thirty-one stands. The extent to which a stand is described by a single plot is dependent on its variability. Some stands are very uniform, while others are complexes of several different communities not separable at the 1:24,000 scale. Such highly variable stands are noted in the comments section (Appendix B, Table 6). In these cases the plot characterizes one of the communities contained within the stand.

Table 3 shows the 20 different bioenvironments (canyonside x elevation zone x landtype combinations) occurring in the elevation zones targeted for sampling, and compares their representation in the sample with that in the study area. Three plots on the north side of the river actually had cool/moist aspects of 310-320 degrees, and three on the south side had aspects of 260-290 degrees. However, these aspects were considered to represent microsites, with the overriding consideration being the general aspect of the landform and the south-horizon angle, which is much steeper for plots on the south side of the river. For example, moist microsites on the north canyonside would be subjected to the higher fire frequency on this side of the canyon, unless they occurred along streams. The sampling design succeeded in that samples were fairly well distributed across the range of bioenvironments present. The major exceptions are landtypes 60S and 61S which did not get sampled south of the river below 2400 ft (a bioenvironment representing less than 1.5% of the RNA). Landtype 60S was also undersampled above 2400 ft.

In general, bioenvironments were undersampled, as a result of several cells being oversampled (e.g. south-24S, north-31S, and north-61U). Landtype 50, which encompasses the largest portion of the RNA, was undersampled on cool aspects below 2400 ft and oversampled above 2400 ft. However, since the precise boundary between elevation zones does not have any biological significance, the pertinent outcome is that stands were sampled across the elevational range of the RNA. Landtype 24S was oversampled, but one of the plots was within the Sam burn. All of landtype 60G occurs in an area of steep cliffs across the river from Isabella Creek, and no attempt was made to sample in this area which represents a small cell and is also very heterogeneous.

Table 4 shows the bioenvironments represented by previously established plots. Their representation in the RNA was not calculated because the landforms involved are mostly too small to be delineated at 1:24,000.

Table 3. Representativeness of the set of stands sampled with reference to bioenvironments in the targeted elevation zone of 2,000 to 4,000 ft, and plot numbers representing each.

Canyon-side	Elev. zone	Landtype	Number of stands sampled	Acres as % of total[1]	No. of stands sampled as % of total	Plots
	ft			%	%	
North	2000-2400	31S	2	0.7	6	77, 80
		50	2	6.0	6	69, 73
		61U	2	1.9	6	78, 84
	> 2400	31S	3	3.6	9	71, 72, 79
		50	1	6.3	3	70
		60S	1	4.3	3	76
		61S	2	10.6	6	74, 75
		61U	0	1.2	-	-
South	2000-2400	31S	0	2.3	-	-
		50	4	19.1	12	63, 83, 94, 95
		60G	0	1.5	-	-
		60S	0	1.3	-	-
		61S	0	0.6	-	-
	> 2400	Rock	0	0.6	-	-
		24S	3	1.6	9	64, 65, 66
		31S	0	1.6	-	-
		50	10	20.2	30	81, 82, 85-87, 89-93
		60G	0	0.6	-	-
		60S	2	14.5	6	67, 68
		61S	1	1.5	3	88

[1] Total acres = 2676; numbers of acres by bioenvironment are shown in Table 2.

Table 4. Bioenvironments represented by permanent plots established in 1991.

Canyon-side[1]	Elev. zone ft	Landtype	Plots
North	1600-2000	10A	4, 5, 8, 9
		15U	6, 11
		31S	10
South	1600-2000	10A	1, 2, 3
		50	7

Data were entered, and saved as text-only (ASCII) files for import into a database or spreadsheet. Five different files were used for different categories of data to simplify viewing. Data files are organized in the same manner as the tables in Appendix B. Separate files were created for data on plot location (Appendix B, Table 1); habitat type and vegetation layers (Appendix B, Table 2); tree density, height, diameter, and age (Appendix B, Table 3); site variables and cover by lifeform and size class (Appendix B, Table 4); and tree cover by species and size class (Appendix B, Table 5). All data files are linked by the seven-digit plot identification numbers.

Copies of the datafiles on disc and of the field data sheets are on file at the USDA, Forest Service, Rocky Mountain Research Station, Missoula, Montana, and at the CDC. Comments from the field data sheets are recorded in Appendix B, Table 6.

Understory cover by species was not entered, as it was not essential to the objectives of this study. Herbaceous cover data are pertinent to determining habitat type, which can be somewhat subjective. This information may also be important to other applications of the data.

Habitat types. Forest habitat types encountered were, from dry to moist: grand-fir/wild ginger *(Abies grandis/Asarum caudatum*), western redcedar/queencup beadlily (*Thuja plicata/Clintonia uniflora*), western redcedar/wild ginger *(T. plicata/A. caudatum*), western redcedar/maidenhair fern *(T. plicata/Adiantum pedatum*), and red alder/maidenhair fern *(Alnus rubra/A. pedatum*; Steele 1971). All habitat types other than *Alnus rubra/A. pedatum* follow Cooper *et al.* (1991).
Wetter habitat types such as western redcedar/lady fern (*Thuja plicata/Athyrium filix-femina*), western redcedar/oakfern (*T. plicata/Gymnocarpium dryopteris*), and western redcedar/woodfern (*T. plicata/Dryopteris* spp; Steele 1971), are typical of the lowest elevations, on toeslopes and terraces along the river, and are represented by plots no. 1 through 10 established in 1991 (Lichthardt 1992).

Western redcedar/wild ginger and western redcedar/maidenhair fern are the predominant habitat types in the RNA. Grand fir habitat types are relatively scarce, occurring mostly on warm aspects on the north side of the river where they are dominated by Douglas-fir. Stand 303-3-035 (plot 89) fits the description of the red alder/maidenhair fern association described from the North Fork by Steele (1971). Although red alder is normally a seral species, these stands are considered to represent an edaphic climax resulting from unstable substrate conditions.

Seral status. Only about a third of the stands sampled are in late-seral or potential-natural-community (PNC) status as defined by Hall *et al*. (1995; Table 5). The remaining stands differ in composition and structure from the potential natural community characteristic of their habitat type. Table 6 lists the stands sampled within each habitat type along with their dominant species, structural condition, and seral status. Table 6 also includes 1991 plots (nos. 1-10) for completeness. The following discussion refers only to 1996 work.

Table 5. Seral status classes and criteria (Hall *et al*. 1995).

Class	Criteria
PNC	The potential natural community under existing environment; seral species scarce to absent.
Late seral	PNC species are dominant, but seral species still persist.
Mid seral	PNC species are approaching equal proportions with seral species.
Early seral	Clear dominance of seral species; PNC species absent or very low in cover; absence of a life-form layer such as absence of trees in a forest PNC.

Tree canopy cover by species and size class (Appendix B, Table 5), was used to classify forest communities as to seral status. Using the system of Hall *et al.* (1995), seral status was based on the relative dominance of PNC species versus seral species, regardless of the structural nature of the stand (Table 5). In applying this system, I considered the canopy layer with the largest foliar volume–generally not the sapling layer, which can have a cover exceeding that of the upper canopy. Intermediate classes ("early to mid seral" and "mid to late seral") were also used where needed. The two major habitat types are represented by a range of seral stages from early-seral to PNC. Early-seral stands are slightly more common overall.

In both the western redcedar and grand fir series, early-seral stands tend to be dominated by even-age, medium Douglas-fir. Some have a component of large and very large survivors. In these stands saplings are generally sparse, a notable exception being plot 67 with a subcanopy of western redcedar saplings. Early-seral stands include the blowdown (plot 86) in which only Douglas-fir poles had any significant cover, and the Sam burn in which only large-tree survivors were present.

Mid- and late-seral stands were found only in the western redcedar and red alder series (Table 6). Mid-seral stands are typically mixtures of medium-size-class western redcedar and grand fir, often with a component of larger survivors. The structure is very variable depending on the presence of survivors or of a sapling subcanopy. Some mid-seral stands can have the character of old-growth due to the presence of large, western redcedar survivors (for example see plot 69). Late-seral stands still have a component of grand fir. However, grand fir tends to persist as a subdominant into old-growth stages of the western redcedar series, as western white pine probably did at one time. Late-seral western redcedar stands were found from 2100 to 3900 ft elevation, on both warm and cool aspects.

Four of the thirty-one stands sampled represent the PNC of the site, three in the western redcedar/maidenhair fern habitat type and one in red alder/maidenhair fern. These stands are dominated by large and very large individuals, and contain large, downed logs. They tend to have low-forb understories, except where shrubs have been released in openings created by dead trees. Seven stands were noted as being old-growth western redcedar based on a combination of structure and composition, but most have a significant grand fir component and were thus classified as late seral. Late seral and PNC stands are more common in the wetter habitat types where stand-replacing fires are rare. All of the late-seral and PNC stands sampled were on landtype 50, “mass-wasted slopes”, where slopes are significantly less steep than the other landtypes and less well-drained.

Structural condition. A structural condition was assigned to each stand based on the dominant diameter class (Table 6). In addition to dominant size class, structural condition also refers to vertical stratification of lifeforms within a stand.

The conifer-sapling layer is an important aspect of stand structure because saplings act as ladder fuels to carry a ground fire into the upper canopy. Where they contribute significant coverage, sapling conifers generally form a separate subcanopy. The only shrub species commonly found in the sapling layer is Rocky Mountain maple (*Acer glabrum*). None of the stands sampled are dominated by saplings. In a few instances, sapling cover exceeded that of the uppermost canopy layer but was subdominant in terms of volume. Only four plots (67, 81, 82, and 93) had sapling canopy cover codes greater than 20 (i.e., 15-25% cover). Sapling densities in these tenth-acre plots were 39, 39, 9, and 41 respectively. In all cases the sapling layer was dominated by either western redcedar or grand fir.

Although poles are considerably shorter than medium trees, their canopies typically merge with that of the medium-tree layer, forming a single canopy layer. This is also true of sapling hardwoods. Only two of the stands sampled are dominated by pole-size trees (plots 86 and 92). Plot 86 is in the 1994 blowdown in which some poles remained standing. Interestingly, plot 92 (stand 303-3-039) is considered to represent the PNC status due to the dominance of western redcedar. Medium trees and very large survivors are also present.

The dominant structural condition is that of medium trees, often a mixture of pole and medium, with open understories and only scattered saplings in the subcanopy. In 25 of the 31 stands sampled, including some stands with PNC status, the single dominant size class is medium trees (9-21 inches dbh), reflecting at least a 50-year interval since the last major fire. Large and very-large survivors of past fires are also commonly present, usually western redcedar and grand fir.

Table 6. Seral status and structural condition of the stands sampled, by plot number within habitat type. Plots 1-10 are monitoring plots established in 1991 and are included for completeness.

Habitat Type[1]	Plot No.	Dominant (-codominant) Species	Structural Condition[2]	Seral Status[3]	Approx. Date of Origin[4]	Notes	Stand No.[6]	Cover type from Stand map[6]
Thupli/Dryopteris	2	Thupli	Large tree	PNC		-	303-04-020	NA
"	8	Abigra-Thupli	Med/lg tree	Mid seral		-	302-02-032	NA
Thupli/Athfil-Adiped	5	Thupli	Very-large tree	PNC		-	302-01-024	NA
Thupli/Adiped	1	Thupli	Large tree	PNC		-	313-07-045	NA
"	3	Thupli	Large tree	PNC		-	303-04-017	NA
"	4	Alnrub	Pole tree	Early		-	302-01-024	NA
"	6	Thupli	Med/lg tree	PNC		-	302-02-030	NA
"	7	Thupli	Very-large tree	PNC		-	303-04-009	Thupli
"	9	Alnru	Pole	Early seral		-	302-02-030	Thupli
"	63	Thupli-Abigra	Med/lg tree	Mid seral		w/ med. tree regen & surviv	303-04-019	Thupli
"	77	Abigra-Thupli	Med/lg tree	Mid seral	1901	-	302-01-003	Thupli
"	79, 80	Thupli	Large tree	PNC	1870	-	302-01-025	Abigra
"	81	Thupli	Large tree	PNC	1846	Subcanopy of Abigra saplings	313-07-045	Thupli
"	82	Thupli-Abigra	Pole/med tree	Mid seral		Closed canopy w/survivors	313-07-046	Abigra
"	83	Thupli	Med/lg tree	Late seral	1868	-	313-07-048	Abigra
"	92	Thupli	Pole tree	PNC		w/survivors	303-03-039	Thupli
"	94	Abigra-Psemen	Med/lg tree	Early seral	1941	30% hardwood cover	303-03-011	Psemen
"	95	Psemen-Abigra	Medium tree	Early seral	1946	-	303-03-030	Abigra
Thupli/Asacau	64[5]	Thupli	Large tree	Early seral		Recent burn w/survivors	303-04-024	Thupli
"	65	Abigra-Thupli	Med/lg tree	Mid to late seral	1836	w/survivors	303-04-027	Abigra
"	66	Thupli-Abigra	Medium tree	Mid seral	1936	Closed canopy	303-04-029	Psemen
"	67	Psemen	Medium tree	Early seral	1924	Subcanopy of Thupli saplings	303-04-039	Psemen
"	68	Psemen-Alnrub	Medium tree	Early seral	1935-41	-	303-04-035	Abigra
"	69	Abigra-Thupli	Med/lg tree	Mid seral	1886-96	Lg. and very lg. survivors	302-01-024	Abigra
"	70	Psemen	Medium tree	Early seral		-	302-01-023	Abigra

- Continued -

Table 6 cont.

Habitat Type[1]	Plot No.	Dominant (-codominant) Species	Structural Condition[2]	Seral Status[3]	Approx. Date of Origin[4]	Notes	Stand No.[6]	Cover type from Stand map[6]
Thupli/Asacau	71	Thupli-Abigra	Med/lg tree	Late seral		w/survivors	302-01-021	Abigra
"	72	Thupli-Abigra	Med/lg tree	Late seral		-	302-01-020	Abigra
"	73	Psemen-Abigra	Medium tree	Early seral		-	302-01-017	Abigra
"	85	Thupli	Large tree	Late seral	1833	Subcanopy of pole/med Abigra	303-03-038	Thupli
"	87	Abigra	Medium tree	Early seral	1911	Closed canopy w/Alnrub	303-03-031	Psemen
"	90	Abigra-Thupli	Med/lg tree	Mid seral		-	303-03-037	Thupli
"	91	Abigra-Thupli	Med/lg tree	Early to mid seral		-	303-03-037	Thupli
"	93	Psemen	Medium tree	Early to mid seral		Subcanopy of Thupli saplings	303-03-040	Thupli
Thupli/Cliuni	10	Thupli	Large tree	Late seral		-	302-01-032	Abigra
"	88	Psemen	Medium tree	Early seral	1916	-	303-03-006	Psemen
Abigra/Asacau	74	Psemen	Medium tree	Early to mid seral		-	302-01-070	-
"	75	Psemen	Medium tree	Early seral		Canopy opened by disease	302-02-017	Psemen
"	76	Psemen	Medium tree	Early seral		-	302-02-033	Abigra
"	86[5]	Psemen	Pole tree	Early seral		Windthrow w/survivors	303-03-050	-
"	84	Psemen	Medium tree	Early seral	1906	-	302-01-030	Psemen
Alnrub/Adiped	89	Alnrub	Medium tree	PNC		-	303-03-035	Psemen
Shrubland	78	Philew	Tall shrub	Late seral		-	302-01-027	Psemen

[1] Follows Cooper *et al*. (1991) except *Alnus rubra/Adiantum pedatum* and *Thuja plicata/Dryopteris* spp. which follow Steele (1971). Species codes are derived from first three letters of genus name followed by first three letters of species name.

[2] Dominant (/codominant) size class of dominant life form (uppermost canopy). For trees this is based on diameter at breast height (dbh) in inches: pole (5-8.9”), medium (9-21.9”), large (22-32.9”), and very large (>32.9”).

[3] Follows Hall *et al*. (1995) as shown in Table 5, using relative dominance of climax species in canopy layer with largest foliar volume.

[4] From age of tree(s) bored in dominant canopy layer.

[5] Permanent plot.

[6] Stand number and cover type are from Forest Service timber stand maps (1984) and the Timber stand management resource system (TSMRS), both available from the North Fork District, Clearwater National Forest.

Ten stands appear to have originated from stand-replacing fires as indicated by an absence of trees in the large or very-large size classes. These stands occur on both north and south aspects. Most are even-age stands of Douglas-fir with a uniform upper canopy and little layering. However, stand 320-1-70 (plot 74) has an open Douglas-fir overstory and a subcanopy of paper birch (*Betula papyrifera*). Stand 303-4-035 (plot 68) is an unusual, Douglas-fir–red alder stand with a very open understory and was the only such stand observed. Douglas-fir did not appear to be the PNC in any of the stands sampled. Stand 302-2-17 (plot 75) is a very open Douglas-fir stand typical of stands affected by root disease, in which tops of dead and dying trees have been wind-thrown.

Stands that are not even-aged generally contain large and very-large fire survivors, generally western redcedar and grand fir. Examples include plots 63, 65, 82, 85, 90, 93 and 94. Large individuals of western larch show up in only one plot (92). These fire survivors generally do not form a distinct upper stratum. Exceptions include three stands which have a distinct bimodal structure with a subcanopy of pole-medium regeneration (plots 92, 93, and 94). These were difficult to classify as to seral status because of the different species composition of the two strata. The upper canopies of these stands may have been opened up by white pine die-off, fire, or decadence.

Relationship of bioenvironment to forest communities. The sample size achieved here, given the large number of bioenvironments, is not sufficient to discern relationships between bioenvironment and forest cover type (composition and structure. An examination of habitat type and stand seral status within the different bioenvironments sampled indicates the following:

- All examples of potential natural communities (PNCs) occurred in western redcedar/maidenhair fern, or wetter, habitat types.
- Late-seral types were only found in western redcedar/wild ginger, or wetter, habitat types.
- Early and mid-seral types were fairly evenly divided between north and south canyonsides, with only slightly more on the north side (9 north vs. 6 south).
- Within the large expanses of landtype 50 south the river, the entire range of seral stages and habitat types were encountered.

Conclusions

Aquarius RNA encompasses not only good representation of both western redcedar and grand fir habitat types, but a range of seral stages and structural conditions within each. The pattern of forest communities is related to major interacting environmental variables, primarily parent material, slope, aspect, and fire history. Stand maps, based on aerial photo interpretation, delineate as accurately as possible the different communities (cover types) at a 1:24,000 scale. However, over time this pattern of communities will change as exemplified by the two disturbance patches created in 1994. Landscape-level monitoring should track such changes and, ideally, should include a more detailed monitoring level designed to detect changes in specific stands. This study was a first step toward detecting such changes in plant community patterns in the RNA. The data also have applications to RNA management and conservation of biodiversity.

Monitoring. The database created here is the first step toward a landscape-level monitoring strategy for the RNA. The objective is to detect changes in the pattern of communities in the RNA resulting from fire, decadence, windthrow, disease and other natural processes that operate over long time periods and at a broad scale.

This study provides baseline data on seral status and structural conditions of a range of forest communities that are already delineated on a stand map of the RNA. The next step is to tie the plot locations used (Appendix A) to similar stand polygons, from an examination of current aerial photographs. In this way, a map of plant communities will be produced that can be used to track changes in the seral status and overstory composition of forest communities within the RNA. Some stands have stand-exam data from 1988 which may be helpful in creating this map. Permanent plots in disturbance patches already created, can be used to characterize community recovery from disturbance.

In addition, the data presented here can be used to select stands for more detailed monitoring. Stands targeted for detailed monitoring should represent the range of seral status and structural conditions shown in Table 6. A second criterion in monitoring site selection must also be accessibility. In addition to the permanent plots already established in the wettest habitat types, in the Sam burn, and in the 1994 blowdown, recommended stands for detailed monitoring, based on seral status, structural condition, and accessibility would be:

- Late seral/PNC: 302-1-021 (medium/large trees with survivors) and 313-7-045 (old-growth stand with a subcanopy of sapling grand fir).
- Mid-seral western redcedar/maidenhair fern: 313-7-046
- Mid-seral western redcedar/wild ginger: 302-1-024
- Early-seral western redcedar/wild ginger: 302-1-023
- Early-seral grand fir/wild ginger: 302-1-030 (medium-shrub understory)

A root-disease disturbance patch is represented by stand 302-2-017. However, this stand is somewhat difficult to access.

Management. Often, the most difficult decisions in RNA management revolve around fire policy. A knowledge of stand structure and fuels can be used to assess 1) the potential for uncontrollable wildfire, 2) the need for prescribed burning or other types of fuels management, and 3) the type of control policy required. Living and dead fuels represent an important parameter in determining fire management policy. Parameters measured in this study that are related to fuels include sapling density (Appendix B, Table 3), canopy cover of saplings, shrub cover, and dead wood cover (Appendix B, Table 4).

Only four plots (67, 81, 82, and 93) were indicative of significant ladder fuels as indicated by sapling cover greater than 45%. The crowns of pole-size trees were generally part of the uppermost canopy stratum. Four plots, 82, 86, 89, and 94, showed high amounts of ground fuels as indicated by dead wood cover greater than 10 percent. Plot 86 was within the 1994 Sam burn.

The fuel levels and tree densities described for most stands sampled in this study do not indicate excessively long fire intervals or a need for fuels management. Much of the RNA is in habitat types (western redcedar/maidenhair fern, western redcedar/ladyfern) in which cool, ground fires are characteristic. Also, the closed-canopy structure of most stands has produced open understories. There was a pronounced lack of a shrub layer in most stands. The apparently natural condition of the stands sampled underlines the need for a fire policy which allows natural fires to burn under some conditions.

Conservation of biodiversity. In terms of biodiversity conservation, it is important to know the existing condition and quality of habitat types in the RNA. That is, the plant community currently occupying the site, whether it is in a relatively natural state, and if not, whether some active management is required. Data presented here indicate that community elements in the RNA are in excellent condition in terms of a lack of human impacts. Fuel levels and tree densities of most stands do not indicate excessively long fire intervals. Habitat types are represented by a range of seral communities, reflecting natural patterns of stand replacing, thinning, and ground fires. In this respect, the RNA represents an important reference area for fire regimes in these habitat types, which can be important to ecosystem management on adjoining lands.

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APPENDICES NOT AVAILABLE ON WEB PAGE
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