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Review of the Hydrology, Geomorphology, Ecology and Management of the Skeena River Floodplain

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Executive Summary

The Skeena River, located in northwest British Columbia, is a large river with a mostly natural flow regime. The floodplain of the lower river covers approximately 16,500 hectares, and is geomorphically very dynamic. Large-scale erosion and deposition processes are constantly changing the location and ecology of floodplain landforms.

The hydrology of the river is characterized by a spring/early summer peak discharge driven by snowmelt; most floods occur during this period. The spring/summer flooding regime contrasts with that of smaller coastal watersheds where fall/winter weather events have a greater effect on hydrology and geomorphology.

Flooding is the main disturbance type on the floodplain. Flooding can influence ecosystems through inundation, sedimentation and erosion. The hydrological dynamics of the Skeena River floodplain are generally intact relative to those of other large river floodplains in North America. This is due to a lack of water control structures such as dams and dikes, though there have been some impacts from highway and railway developments. Disturbances by fire, wind, disease and insects play a minor role in structuring the ecosystems of the floodplain.

The river has many large in-stream wood deposits, which are important to the river's dynamics and island formation and stability. The logjams also provide important fish habitat.

Ecosystems of the area are classified into three types based on flooding dynamics and the resulting vegetation: low, middle and high bench. These ecosystems form a dynamic gradient and successional sequence that is influenced by the flooding regime. The deposition of sediments over successive flooding events gradually builds up, raising the landforms and changing the flooding regime and growing conditions.

The high bench Sitka spruce – Salmonberry ecosystem is Red-listed by the BC Conservation Data Centre and the middle bench Cottonwood – Red-osier dogwood ecosystem is Blue-listed. These ecosystems dominate the forested areas on the floodplain. Only a small proportion of the original high bench forest remains in an undisturbed condition. The amount of undisturbed middle bench is unknown due to difficulties in differentiating this type from harvested stands on aerial photographs.

Many rare plant, wildlife, and fish species may occur on the floodplain, however, inventory information on most species is lacking. The floodplain plays a role in maintaining regional biodiversity by providing low elevation coniferous and deciduous riparian habitat where these habitats are not common, and in providing seasonal habitat for migratory species.

Forest harvesting on the floodplain started in the late 19th century, and reached a peak in the late 1950's and early 1960's. Most of the resultant secondary stands are dominated by deciduous species, primarily black cottonwood with some red alder, and have a conifer component that is highly variable in density. Some of these secondary stands are now being harvested along with some primary deciduous stands. Attempts have been made to establish conifer plantations on the alluvial floodplain sites. Most of these attempts have failed because of intense competition from brush and deciduous trees, flooding, and animal damage.

Present forest management practices include increasing the focus on deciduous species for crop trees and fibre production, and retaining existing conifer regeneration to provide future coarse woody debris and stand structure. Coarse woody debris is important on the floodplain in maintaining biodiversity and in supplying regeneration sites where there is intense competition from shrubs. Management of coarse woody debris will play an important role in the future regeneration dynamics of these floodplain ecosystems.

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1.0 Introduction

This review of the natural and human history of the floodplain of the lower Skeena River was initiated to provide background information to support future management of the area. Management to date, especially early forest harvesting, has not considered ecosystem impacts of management practices. The impetus for this work has come from the Kalum Land and Resource Management Plan (LRMP) (BC Ministry of Sustainable Resource Management 2002) and resource managers concerned about the future of the area.

The Kalum LRMP has directed managers to conserve vulnerable, rare, threatened, and endangered species and their habitat and plant communities. Strategies listed to achieve this objective include:

- Identify and conserve vulnerable, rare, threatened and endangered habitats.
- Determine location and extent of Red- and Blue-listed species within the timber harvesting landbase.
- Identify and manage critical habitats and plant communities for vulnerable, rare, threatened and endangered wildlife species and plant communities where resource development is planned.

The main plant communities of the floodplain, the high bench Sitka spruce – Salmonberry and the middle bench Black cottonwood – Red-osier dogwood, are Red- and Blue-listed, respectively, by the BC Conservation Data Centre (CDC) (BC Ministries of Sustainable Resource Management and Water, Land and Air Protection 2004).

There are three other components to this project. Firstly, a Terrestrial Ecosystem Mapping (TEM) component is using aerial photographs from 1947 and 1994/2003 to determine the historical and present extent of the Red- and Blue-listed plant communities and their condition. Secondly, a research project is examining the forest structure at different successional stages and after harvesting. Thirdly, the condition of rare ecosystems was ranked using aerial photographs taken in winter, and using the TEM polygons. The results of these components will be presented in a separate report.

2.0 Study Area Description

The Skeena River floodplain study area is downstream of Terrace, British Columbia, and encompasses parts of the Kalum and North Coast Forest Districts (Figure 1). The area is about 75 kilometres long and 1.5 to 3 kilometres wide, with a total area of 16,500 hectares. Approximately 10,500 hectares are vegetated, 1300 hectares consist of gravel bars, and the remainder is river, varying with river stage.

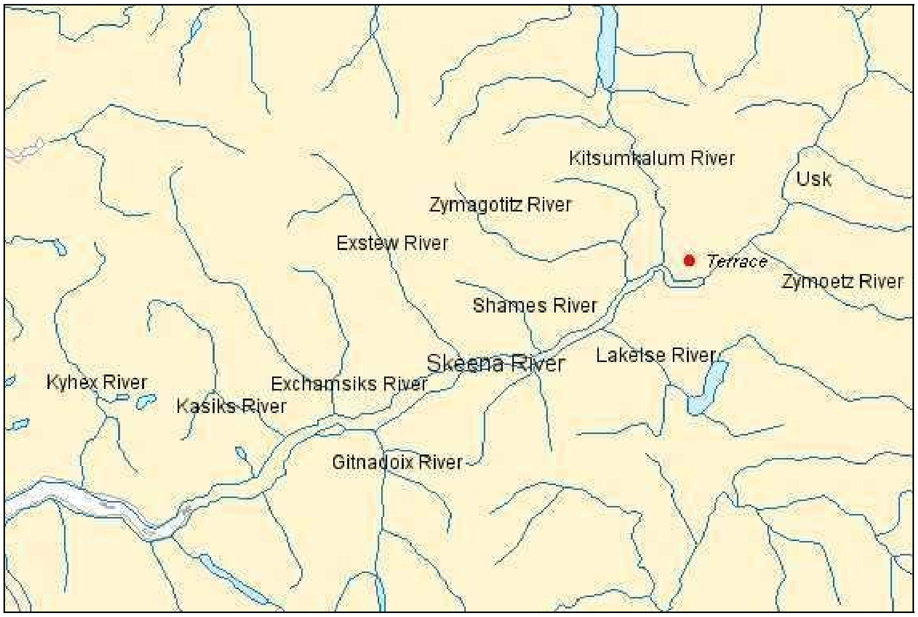

Figure 1: Map of the Skeena River floodplain.

Major tributaries to the Skeena in the area are the Kitsumkalum, Zymagotitz (Zymacord), Lakelse, Shames, Exstew, Exchamsiks and Gitnadoix Rivers. A summary of discharge information for some of these tributaries shows that while they have smaller discharges than the Skeena, peak discharges are often simultaneous (Table 1).

Table 1: Maximum recorded discharge and mean annual discharge for rivers in Skeena Watershed in or near the study area with water gauging stations (Environment Canada 2004).

River	Period of Record[1]	Maximum Recorded Discharge		Mean Annual Discharge (m^3/sec)
		(m^3/sec)	Date	
Exchamsiks	1962 - present	864	Nov. 1, 1978	43
Kitsumkalum	1929 - 1952	883	June 3, 1936	123
Skeena	1928 - present	10,194	June 3, 1936	910
Zymagotitz	1960 - 1995	549	Oct. 10, 1974	24
Zymoetz	1952 - present	3,140	Nov. 1, 1978	137

1. Record may not be continuous for entire period.

At the Usk water gauging station, 20 kilometres upstream of the study area, the Skeena River has a mean annual discharge of 910m^3/sec (Table 1). At the mouth the mean annual discharge is 1730m^3/sec (Leopold 1994). The Skeena ranks 46th in the world in volume of ocean discharge.

The catchment area of the Skeena at Terrace is 45,600 km^2 (Water Management Consultants 2001). Tidal influence extends to just upstream of Polymar Creek, approximately 30 kilometres east of the Khyex River (Beaudry 1990). Here the frequency of vegetated islands in the Skeena dramatically decreases and the study area ends.

As of 2004, there were two administrative units on the floodplain: TFL (Tree Farm Licence) 1 held by New Skeena Forest Products Ltd., and the Kalum TSA (Timber Supply Area), both administered by the Kalum Forest District in Terrace, which is in the Northern Interior Forest Region. BC Timber Sales also operates within the area.

3.0 Climate

The climate is monitored at Terrace at the eastern end of the study area (Environment Canada 2005) and was monitored for three years (1986 to 1988), at Salvus in the west (Beaudry 1990). The climate is submaritime and has warm moist summers with significant dry periods and very wet winters (Banner et al. 1993). There is a strong precipitation gradient across the area with average annual precipitation of 1160 milimetres at Terrace and 1783 milimetres at Salvus. At both sites, the driest months are May, June and July and the wettest are October, November and December. The mean annual temperature is 6.9^{o}C. The coldest month is January (-3.5^{o}C) and the warmest months are July and August (16.5^{o}C). Because winter air temperatures are often close to 0^{o}C, the maximum snowpack depth is highly variable. Some years experience an ephemeral snowpack with multiple accumulation and melting periods and other years record accumulations of 2.5 metres or more (Beaudry 1990).

4.0 Geomorphology

The floodplain landform is formed by sediment deposition as the gradient of the river decreases and confinement of the river by bedrock declines towards the estuary (Hogan and Schwab 1990). As the velocity of the water decreases, the bedload of the river is deposited on the floodplain, which consists of a series of islands in the river channel and adjacent mainland areas.

The floodplain sediments, which can exceed 20 metres in depth, overlie glaciomarine, marine, or deltaic sediments laid down on the sea floor when the area was a fiord. These sediments were progressively covered as the Skeena River estuary and floodplain moved westward down the valley in postglacial times. Terraced, inactive fluvial deposits are common along the Skeena between Kispiox and Cedarvale, but are rare downstream of the Lakelse River (Clague 1984).

Wandering gravel bed rivers in northern BC had larger floodplains during the Little Ice Age or neoglacial period, which ended about 150 years ago, than at present (Gottesfeld and Johnson Gottesfeld 1990, Gottesfeld 1997). These rivers were probably more braided and deposited more gravel than present-day rivers. The older deposits thus tend to be situated towards the outer edges of the current floodplain (Gottesfeld 1997). This history is likely to apply to the Skeena River, which is downstream of the Morice River described by Gottesfeld and Johnson Gottesfeld (1990).

The temporal stability of floodplain landforms along the Skeena River was mapped by Hogan and Schwab (1990), using a series of aerial photos from 1947 to 1987. This mapping showed that though landforms are constantly changing through erosion and deposition events, the degree of instability can vary widely between areas. The floodplain downstream of Terrace is a net depositional zone. Some river reaches are erosional zones and others are depositional zones.

Fluvial sediments on the floodplain have a textural gradient. The sediments generally become finer downstream. Gravel is the dominant sediment from Terrace to the Gitnadoix River. Farther west, gravel is the main sediment only on active bars, with sand more common elsewhere. Silty sand and sandy silt are the most abundant sediments (Clague 1984) west of the Khyex River. The gravel deposits are usually capped by layers of sands and silts, typically more than 1 metre thick, deposited by high water events (Beaudry 1990).

The Skeena River has an anastomosing pattern of several main channels with relatively stable vegetated islands and side channels. The islands range in size up to 300 hectares, and are separated by channels of varying width and activity. Channels can be abandoned and slowly filled in with sediments when logjams block inflow. The sediments deposited in the abandoned channels are typically finer in texture than in other nearby areas, due to deposition by low energy water. Abandoned channels can be re-excavated and reactivated as the river changes its course over time.

Tributary rivers and the degree of valley wall confinement can influence deposition and erosional processes. Depending on the sediment dynamics of the particular watershed, incoming rivers can be minor or important sediment sources. Soil erosion, affected by geography and land use, influences sediment dynamics. For example, lake-headed river systems produce relatively less sediment than systems with steep short watersheds. Where there is little valley wall confinement, sediments tend to accumulate, while in confined areas sediments are transported to downstream areas (Hogan and Schwab 1990).

The stability of floodplain landforms can be influenced by vegetation, especially during early stages when gravel bars are colonized by primary successional vegetation (Hogan and Schwab 1990). This vegetation reduces erosion and traps fine-textured sediments. On older landforms where deposits are thicker, vegetation has little influence on this process as most soil erosion occurs in the coarser gravels and cobbles below the root network. This erosion leaves a concave bank profile that eventually collapses (Gottesfeld and Johnson Gottesfeld 1990, Hogan and Schwab 1990).

The Biogeoclimatic Ecosystem Classification (BEC) system divides active floodplain ecosystems across BC into high, middle and low benches based on vegetation, flooding frequency and other factors (Banner et al. 1993, McLennan 1995a, McKenzie and Moran 2004). The study area floodplain has little overall relief. Local ground elevation varies by 1 to 2 metres, mostly due to levees and abandoned channels (Beaudry and Hogan 1990). The floodplain does not have benches in the sense of terraces and scarps or risers as found further upstream (A.S. Gottesfeld, personal communication 2004), though there are distinct vegetation types based largely on topography.

Figure 2: Bank erosion on the Skeena River showing the concave bank profile and erosion occurring below the rooting depth.

4.1 The Influence of Wood

Knowledge of the functional importance of in-stream wood on the dynamics of river systems is increasing (Gregory 2003).

Wood influences river system geomorphology through:

- Sediment routing and storage.
- Channel dynamics and processes.
- Channel morphology (Montgomery et al. 2003).

The magnitude of the influence of wood on these processes can vary with river size (Gurnell et al. 2002). In large rivers, wood influences large-scale geomorphological processes such as sediment storage, island creation and retention, and riparian habitat formation (Naiman et al. 2002).

Figure 3. Example of a large accumulation of wood in numerous logjams along the Skeena River. Photo taken in April 2005 at low flows (distance across photo approximately 600 metres).

Accumulations of in-stream wood are common on the Skeena River floodplain. Some logjams exceed 20,000 m^3 in volume (Gottesfeld et al. 2002). Accumulations of wood are critical for island development and stability because they facilitate downstream deposition of sediments (Fetherston et al. 1995, Abbe and Montgomery 1996, Gurnell and Petts 2002). This can be especially important in anastomosing rivers (Gurnell and Petts 2002, Montgomery et al. 2003), such as the lower Skeena (Schwab et al. 2002). There is evidence that the decline of wood inputs into European rivers contributed to loss of islands in the rivers, which are now mostly single thread, incised rivers (Gurnell and Petts 2002).

Wood accumulations can increase erosion by diverting flows to areas that are subsequently eroded. On the Morice River, logjams are reported to initiate channel reorganization as they form at channel bends and constrictions during floods, diverting the flow around the blockage (Gottesfeld and Johnson Gottesfeld 1990). Logjams often form at the inlets to channel branches, reducing the flow into the now-blocked channel, even during floods. This may cause increased deposition rates in the channel, with the result that it may eventually be closed to main channel flow (Hogan and Schwab 1990). Logjams can persist for long periods of time, but when they break down, erosion rates in the area may become much greater (Hogan and Schwab 1990, Abbe and Montgomery 1996).

Wood can have important effects on other components of river ecology. Gregory et al. (2003) describe the influence of wood on aquatic biodiversity, fish, wildlife, and nutrient dynamics. The erosion and deposition processes influenced by wood can increase the biodiversity of river systems by providing a mosaic of habitat types and forest ages (Richards et al. 2002). Fish habitat created by wood in a large river like the Skeena, where logjams and backchannels are important (Bustard 1991, Bustard 1993), is different in character than that created by wood in smaller waterways, where wood is important in pool formation (Naiman et al. 2002). On the Skeena, logjams provide fish habitat and buffer water flow into backchannels. Skeena River backchannels are commonly used as juvenile salmonid rearing habitat (Bustard 1991, Bustard 1993), as are the logjams themselves. Bustard (1991) found that logjams were heavily used as juvenile rearing habitat by steelhead and chinook over the winter and into spring, and by coho in late winter and summer.

Sources of wood are both local and external to the study area. Erosion of stream banks within and outside the study area during spring snowmelt and fall run-off is likely the major source of wood. Major episodic events such as landslides in large tributaries can also be important sources of wood. For example, an uncommon, large landslide in June 2002 deposited over a million cubic metres of sediment and hundreds of pieces of wood into the lower Zymoetz River; a major tributary which enters the Skeena about 15 kilometres upstream of Terrace. In the first few days after the event, coarse woody debris (CWD) (broken trunks, limbs, root wads) was distributed throughout the lower 15 kilometres of the Zymoetz River and was observed being exported into the Skeena River at rates of 30 to 40 pieces per hour. Over the next several months, logs from the landslide were found up to 25 kilometres downstream of the confluence of the Zymoetz and Skeena rivers on gravel bars and in log jams. In contrast to typical weathered wood in the Skeena, this wood debris had embedded fractured rocks, splintered ends, a lack of bark and un-weathered colouration. No other sources of rock-embedded wood were found at the time (S. Jennings, personal communication 2004).

Forest practises and other land uses have probably altered the patterns of CWD input into the Skeena River. Species composition, piece size and shape, timing, and volume of input (Hyatt and Naiman 2001, BC Ministry of Forests 1990) could all be changed. These changes could affect the formation and longevity of logjams, as small deciduous trees decay faster than large diameter coniferous logs (Hyatt and Naiman 2001). Stumps may not travel the same distance or to the same locations as logs. Timber harvesting and other upstream activities may affect the overall dynamics and stability of the islands and backchannels in the floodplain.

5.0 Hydrology and Flooding

Floods along the Skeena River are of two types:

- Spring-early summer floods caused by melting of the winter snow pack throughout the watershed.

- Fall-winter floods caused by intense rainfall events sometimes accompanied by rapid snowmelt from rain-on-snow. These fall-winter floods tend to be associated with localized weather events.

Ice jam-caused floods have been reported from areas upstream of Terrace and on the Bulkley River, a tributary to the Skeena, but have not been recorded in the study area (Septer and Schwab 1995).

The largest annual peak flows are usually in spring and early summer (Figure 4), as large rivers such as the Skeena are relatively insensitive to localized severe storms (Clague 1984). In 72 years of records for the Skeena River at the Usk water gauging station, the largest annual peak flow has been in fall instead of spring in only three years (Environment Canada 2004).

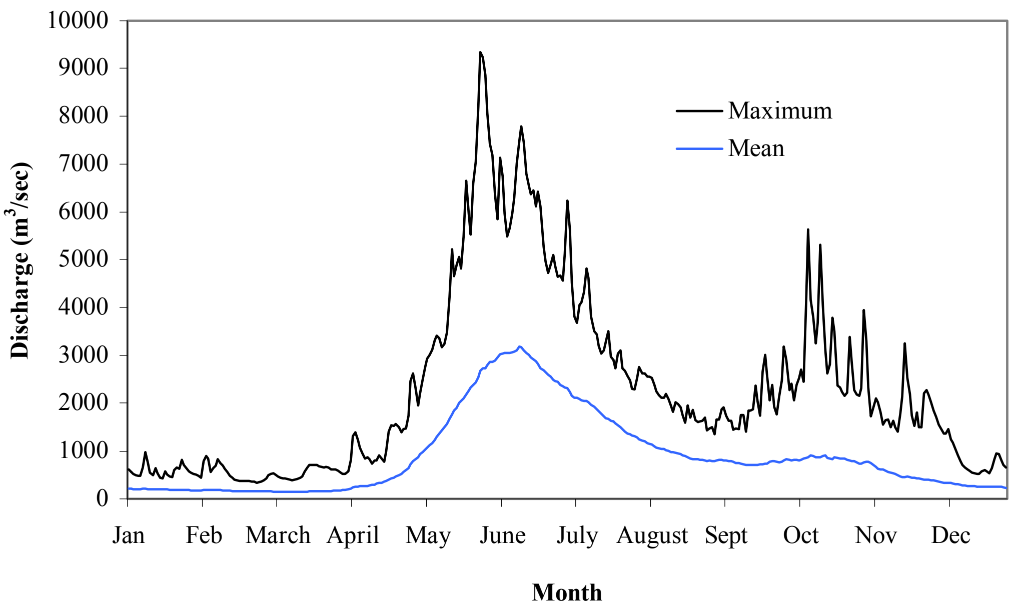

Figure 4. Hydrograph of maximum daily and mean daily discharge of the Skeena River at Usk between 1928 and 2004.

The largest recorded floods on the Skeena River, in order of diminishing size, occurred in 1936, 1948, 1972, and 1964 (Figure 5), (Environment Canada 2004, Septer and Schwab 1995). Details of damage done by these and other smaller floods can be found in Septer and Schwab (1995). These record floods undoubtedly deposited large amounts of sediment on the floodplain and eroded large parts of islands, but there is little information available about consequences of the floods away from inhabited areas and road and rail infrastructure. The 1948 flood was determined to be a 1 in 200 year event (Table 2) (Water Management Consultants 2001), while the 1936 flood was considered a 1 in 300 year event. These assessments should be interpreted with caution, however, as failure of the recording devices during some large floods such as the 1936 event (A. Gottesfeld, personal communication 2004), means these large events were not used in the flood frequency calculation by Water Management Consultants (2001).

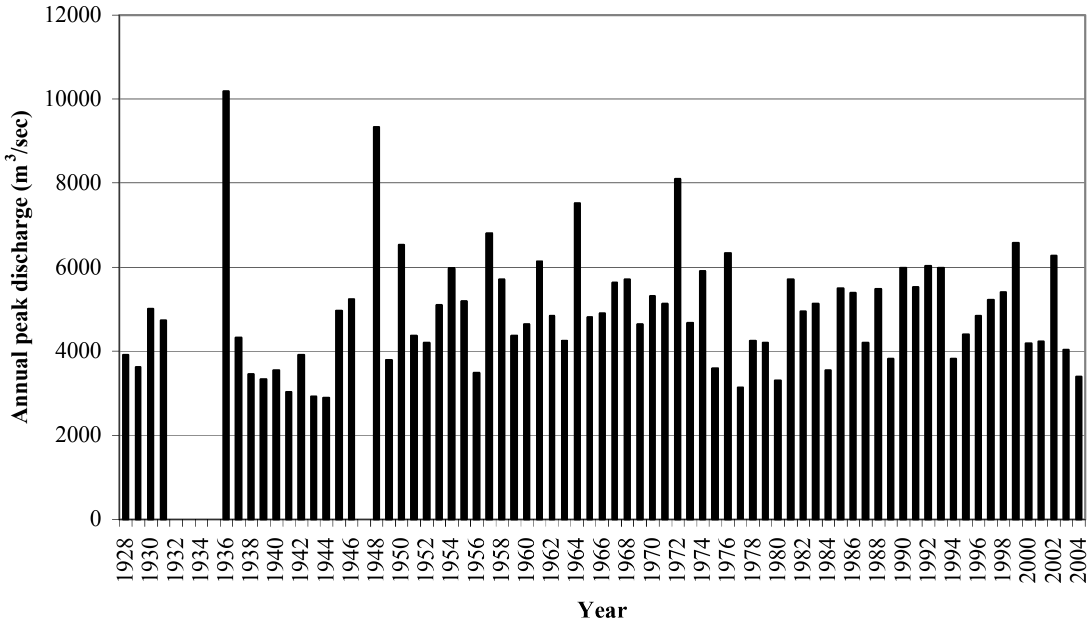

Figure 5: Annual peak discharge of the Skeena River at Usk.

Table 2: Flood return period of the Skeena River at Usk for selected discharges (Weiland 2002, Water Management Consultants 2001).

Return Period (years)	Maximum Instantaneous Discharge (m^3/s)
2	4,000
5	5,850
10	6,600
20	7,300
50	8,200
100	8,800
200	9,600

The gauging station at Usk may miss some large floods in the study area because large flows can come from tributaries such as the Zymoetz River that are downstream of the Usk recording station. In 1978, when a multi-day rainfall event caused extensive flooding damage in the lower Skeena (Septer and Schwab 1995), the Zymoetz River attained a peak flow of 3,140 m^3/s, while the Skeena River at Usk measured a peak flow of just 4,250 m^3/s over the same period (Water Management Consultants 2001).

The overall hydrological pattern indicates that the lower Skeena River flooding regime is determined primarily by regional climatic events rather than by local events, due to the large size and interior location of most of the watershed. This contrasts with smaller, strictly coastal watersheds in which the highest annual peak flows are commonly caused by intense fall or winter rainfall events. The large Nass River watershed, 90 kilometres to the north, does not extend as far inland as the Skeena River watershed. Fall floods are much more common on the Nass than on the Skeena, with 12 of 65 recorded annual peak flows occurring in fall (Environment Canada 2004).

Overbank flooding can inundate low-lying areas several times a year, and is the most important flooding process on the Skeena River floodplain. Portions of the floodplain may be passively flooded if the water table rises above the ground surface. The duration of inundation depends on whether the area can drain laterally or whether water ponds on site, i.e., whether low areas are open at one end allowing free drainage or closed to direct drainage back to the river (Beaudry and Hogan 1990).

There is little information relating the size of flood events to the depth and length of inundation and depth of sediment deposition on benches of varying height. Some information on flood heights can be obtained from flood damage scars (Gottesfeld 1996) and from silt deposition on tree boles. The annual range in river height within the study area is not regularly measured. However, Davies and Gottesfeld (1986) measured a 3.75 metre difference between the June high water level (5380 m^3/sec, 1 in 2 year event) and the mid-September water level, and state that the island surfaces were typically 2.2 to 4.25 metres above the mid-September water level. Bustard (1991) measured a 4.7 metre range in water levels on a backchannel near Exchamsiks River in 1990; an average peak discharge year. Beaudry and Hogan (1990) recorded widespread flooding on their study island in the North Coast FD with water depths of up to 2 metres in a year when the peak flow was a 1 in 4 year event (5480 m^3/sec). McLennan (1999) states that on a field visit to block 504-101 near Andesite Creek in September 1999, there was evidence of flooding to a depth of 1.75 metres on the middle bench and 0.65 metres on the high bench, with the deposited layer of sand and silt from 15 to 40 centimetres deep. He estimated this to be a 1 in 20 year flood event, however, the 1999 flood was a 1 in 10 year event, being the 7th largest recorded annual peak flow (6580 m^3/sec). These observations indicate that middle benches are flooded nearly every year and that high benches are flooded at least every 10 years. However, because the height of high bench ecosystems varies across the floodplain, flooding frequency will also vary.

Other fluvial processes influence plant communities of the floodplain. River channels become blocked by logjams or abandoned due to river course changes. These abandoned channels gradually fill with higher density silt or clay deposits, and thus have different soil drainage characteristics than areas with lower density, coarse textured deposits (A. Gottesfeld, personal communication 2004). However, Beaudry and Hogan (1990) found no differences in soil characteristics among areas with different flooding regimes.

Perched water tables may occur in areas with fine textured soil deposits. Areas farther from the river channel may experience delayed flooding due to lags in water table rises, but these same areas may retain high water tables for longer periods because of longer drainage distances (Beaudry and Hogan 1990). Beaudry and Hogan (1990) used these spatial characteristics of flood regimes to develop a flood hazard classification system to guide establishment of Sitka spruce plantations. For more information on this research see Section 9.2 of this report.

6.0 Ecology

The Skeena River floodplain lies mostly within the CWHws1 (Coastal Western Hemlock wet submaritime) biogeoclimatic variant, with the CWHvm1 (CWH very wet maritime) boundary occurring near the mouth of the Gitnadoix River (Banner et al. 1993). Thus, most of the study area is submaritime, and is transitional between the very wet maritime and wet subcontinental subzones.

The ecosystems of the floodplain are classified as high, middle and low benches (Table 3). Each has distinctive hydrological properties and plant communities (Banner et al. 1993, McLennan 1995a, MacKenzie and Moran 2004). The successional development of these ecosystems and the development of the landform they occupy progress in tandem (McKenzie and Moran 2004). Sediment accumulation and changes in channel morphology that reduce flooding frequency cause gradual shifts in seral communities and a progression towards high bench ecosystems (McKenzie and Moran 2004).

Table 3: Correlation between different ecosystem classifications.

Ecosystem	Banner et al. 1993			McKenzie and Moran 2004	
	Site Association Name	**CWHvm1 Code**	**CWHws1 Code**	**Site Association Name**	**Code**
High bench	Sitka spruce – Salmonberry	09	07		n/a
Middle bench	Cottonwood – Red-osier dogwood	10	08	Cottonwood – Red alder – Salmonberry	Fm50
Low bench	Cottonwood – Willow	11	09	Sitka willow – False-lily-of-the-valley	Fl50

The BEC system characterizes each ecologically significant portion of an area with a specific climax plant community and these areas can be grouped according to their site potential or site association. Thus, areas in one site association will have similar growing conditions (climate, soil moisture and nutrients) regardless of their successional stage (Pojar et al. 1987). Floodplains present a special case for classification. A low bench ecosystem, though it may eventually become a middle and then high bench ecosystem through succession, will have different ecological growing conditions than these other sites because of the changing flooding regime. As such, the climax high bench ecosystem cannot be used to differentiate sites in earlier successional stages because the growing conditions are different among low, middle and high benches, so each successional stage is assigned its own site association (McLennan 1995a).

6.1 Low Bench Ecosystems

Two types of low bench ecosystems have been recognized:

- Sandy-skeletal, which occur beside main channels, at the leading edge of point bars, and on low-lying islands.

- Loamy, which occur in infilling backchannels where the sediment texture is finer (McLennan 1995a).

In both types, materials will usually be overlying gravelly base materials. Low benches are usually located directly adjacent to the river or backchannels and are flooded for moderate periods (less than 40 days) during the growing season. The annual deposition and erosion of sediments and scouring by moving water limits the development of understory vegetation and humus layers. The vegetation is dominated by Sitka and Pacific willows, black cottonwood, and red alder with sparse herb and moss layers (Banner et al. 1993, McKenzie and Moran 2004). Silviculture opportunities are limited on low benches due to the severe flooding regime, and they should be preserved for their high wildlife values (McLennan 1995a).

Figure 6: Typical low bench ecosystem along the Skeena River at Whitebottom Creek (photo taken April 2005).

6.2 Middle Bench Ecosystems

Middle bench ecosystems form as sediment deposition continues and build up of sands and silts lowers flooding frequency and duration. Middle benches are flooded for 10 to 25 days during the growing season, but may have elevated water tables for prolonged periods. Reduced flooding allows flood-tolerant black cottonwood and red alder trees and shrub species to become dominant. Establishment of conifers – scattered Sitka spruce and redcedar – occurs on elevated microsites (McLennan 1995a). The shrub layer is usually vigorous with thickets of salmonberry, red osier dogwood, red elderberry, and thimbleberry. Herb and moss layers are sparse to well-developed depending on flooding history and canopy development

(Banner et al. 1993, McKenzie and Moran 2004). Middle benches are most prominent on the largest coastal floodplains where the highest and most persistent flooding occurs in May and June. Middle bench ecosystems are well suited to cottonwood management, but also have high biodiversity values (McLennan 1995a).

Figure 7: Typical middle bench ecosystem along the Skeena River at Lakelse River. The green area on the right is an older landform with an abundant conifer component. The area on the left is younger and has either fewer conifers or they are smaller and not yet visible through the deciduous canopy (photo taken April 2005).

6.3 High Bench Ecosystems

As deposition of sediments continues to raise landforms above the river to the point where floods are infrequent, conifer-dominated high bench ecosystems develop. High bench ecosystems often occur on levees (McLennan 1995a). They are only periodically and briefly inundated (less than 10 days per year) but have lengthy periods of subsurface flow in the rooting zone. Flooding occurs only during extreme events, which may occur several times in a year or once in several years. The lack of frequent or prolonged flooding allows coniferous trees, especially Sitka spruce and redcedar, to eventually dominate. The shrub layer is dominated by salmonberry and devil's club. Lady fern and ostrich fern are common in the herb layer and leafy mosses in the ground cover layer (Banner et al. 1993). High benches usually dominate the floodplains of medium sized watersheds. Due to the reduced flooding, high bench sites provide the opportunity to manage deciduous and coniferous species. Other resource values are important on high bench sites and require careful consideration before applying management treatments (McLennan 1995a).

Natural forests on the high benches of the Skeena and Nass rivers typically had a low stocking rate of Sitka spruce and redcedar with a canopy closure of less than 30% above a continuous cover of shrubs. Tree diameters ranged from 0.8 to 2.0 metres. These trees were established mainly on elevated stumps and mounds and better-drained cutbanks and levees (Yole 1986 in Inselberg et al. 1990, Davies and Gottesfeld 1986).

Figure 8. Typical high bench ecosystem along the Skeena River (centre) with secondary stands to the left and the toe of an avalanche chute on the right (photo taken April 2005).

6.4 Soils

The soils of the floodplain are young due to the recent nature of the fluvial deposits. The dominant soil types are poorly developed Brunisols or cumulic Regosols (Banner et al. 1993, MacKenzie and Moran 2004) with few or no coarse fragments above the gravelly substratum. Gleysols or mottles are found in low-lying sites where water sits for longer periods or in former back channel areas where clays have accumulated. Soil particle size is mostly sandy to silt loam. High bench sites tend to have finer textured soils. Silts are also found on all ecosystem types. Humus layers are mostly quite thin (3-10 centimetres thick) and are classified mainly as moders with occasional mors (Banner et al. 1993). High bench sites tend to have thicker humus layers than middle and low bench sites, reflecting intensity of flooding events and accumulation of coniferous needle litter.

6.5 Ecosystem Dynamics and Productivity

Differences in ground elevation among the three ecosystems described above are no more than 1 to 2 metres (Beaudry and Hogan 1990), and physical boundaries between the ecosystems are indistinct as there are no risers or scarps separating them, as there are in terraces (A. Gottesfeld, personal communication 2004). The ecosystems differ mainly through subtle changes in relative landform height and/or soil texture, and concomitantly in growing conditions. These small changes in landform height can have a large effect on the plant community due to changes in flooding duration (Beaudry and Hogan 1990). This affects establishment of conifers more than establishment of cottonwood and red alder, which have greater tolerance to inundation and high water tables.

It is unclear if tree establishment on the Skeena River floodplain is continuous or episodic, and if deciduous and coniferous species recruit at the same time, especially on previously harvested sites. Research on other floodplains has shown that establishment of cottonwood and willows is related to processes that provide bare moist surfaces for seed germination, such as flooding, channel narrowing and meander development (Nanson and Beach 1977, Viereck et al. 1993, Scott et al. 1996). On the Tanana River floodplain in Alaska, white spruce seedling establishment on the floodplain is episodic, related to seed production and dispersal (Walker et al. 1986). In years of high water levels after a year of high seed production, water-transported spruce seeds germinated on the fresh silt deposited over the forest floor. Seeds of other tree species were also deposited and germinated, but did not survive due to higher light requirements and lower tolerance of competition (Walker et al. 1986).

The dominance of sites by either cottonwood or red alder could be an effect of timing of seed release and response to flooding disturbance. Cottonwood has life history traits associated with reproduction and establishment after spring fluvial events, such as snowmelt and stormflows. Cottonwood seeds, which are only viable for a short period, are released in the spring around the time that floodwaters normally recede. Germination is rapid under these conditions (Braatne et al. 1996). Red alder releases most of its seeds in the fall with germination occurring the following spring (Harrington et al. 1994). Although a mineral seedbed is most favourable, red alder seeds can successfully establish on undisturbed soils (Haeussler 1988). Where there is recent or frequent flooding cottonwood may dominate; where flooding is less recent or frequent red alder may dominate (S. Haeussler, personal communication 2004).

Little is known about long-term forest dynamics on high benches. Using transition probabilities derived from plot data at Exchamsiks River Park, Burton (2000) concluded that the high bench Sitka Spruce – Salmonberry community is only partially self-maintaining. Based on current stand structure, shrubs, red alder and hemlock were predicted to increase relative to Sitka spruce in future generations.

In Washington and Oregon some riparian sites are becoming dominated by shrub fields due to a lack of conifer regeneration (Peterson et al. 1997, Hibbs and Bower 2001). Beach and Halpern (2001) have shown that conifer regeneration in riparian forests is dependent on interaction of proximity to seed source, presence of CWD and density of shrub cover, especially salmonberry. On the Skeena River floodplain, the extensive history of conifer harvesting could mean that seed availability is a limiting factor in conifer regeneration in some areas. Beach and Halpern (2001) found no regeneration in areas greater than 170 metres from the nearest potential seed source. During fieldwork on the Skeena River floodplain, natural shrub-dominated areas were observed adjacent to Sitka spruce stands where seed limitation would not be a problem. This indicated that the presence of a seed source alone is not always adequate to ensure conifer regeneration on high bench riparian areas.

Floodplains are among the most productive growing sites for trees in BC with a site index of 41 metres at 50 years in pure even-aged cottonwood stands (Bunce 1990) and 33 to 30 metres at 50 years for Sitka spruce on high and middle benches in the CWHvm1 and CWHws1 (Peterson et al. 1997).

6.6 Disturbance Regime

The CWHvm1 is classified as Natural Disturbance Type (NDT) 1 and the CWHws1 as NDT2 (BC Ministry of Forests 1995a). Natural Disturbance Type 1 ecosystems have rare stand-initiating events with a mean return interval of 250 years or more for the CWH, while NDT2 ecosystems have infrequent stand-initiating events with a mean return interval of about 200 years for the CWH. This difference in NDT between the CWHvm1 and CWHws1 reflects the gradient of decreasing precipitation from the western to the eastern slopes of the Coast Range. The NDT classification, however, is intended for large land units such as a biogeoclimatic subzone, and does not apply to rare landforms such as floodplains. A recent review of disturbances on the North Coast of BC focuses on upland ecosystems and provides little information on large floodplains (Dorner and Wong 2003).

6.6.1 Fire

The importance of fire in coastal floodplain forests has not been studied, and there is no consensus on the importance of fire on interior floodplain forests. The results of studies on the Tanana River in Alaska have been contradictory with regard to frequency of fire on the floodplain (Magoun and Dean 2000). Mann et al. (1995) challenged the assumption that fire was infrequent on floodplains by finding frequent evidence of fire, and concluded that fire was a common and widespread ecological factor. Adams (1999 *in* Magoun and Dean 2000), however, discounted the importance of fire on the Tanana River floodplain, citing flooding and herbivory as being more important, and Welbourn (1983 *in* Magoun and Dean 2000) estimated a fire cycle length of 222 years for bottomland white spruce versus 152 years for upland white spruce. On the upper Laird River in Yukon, fire was determined to be a less frequent disturbance on the floodplain than on the surrounding upland forest areas (Applied Ecosystem Management 1998). In the Foothills Model Forest Area in Alberta, at the local scale, fires are less frequent in riparian areas in complex landscapes when compared to surrounding upland forests, but not in flat landscapes (Andison and McCleary 2002). At the landscape scale, fires were as common in riparian areas as on the landscape on average, based on stand age (Andison 2001), though the study did not account for the younger age of fluvial landforms.

6.6.2 Flooding

Flooding is the primary cause of ecological disturbance on the Skeena River floodplain, although some authors do not consider flood pulses to be disturbances but an integral part of ecosystem dynamics (Bayley 1995). Flooding is considered to be a stand-maintaining disturbance (Dorner and Wong 2003), except when erosion occurs removing forested areas. Erosion on the Skeena doesn't occur only during floods. Active erosion has been observed in late summer when flows were well below their seasonal peak (A. de Groot, personal observation 2004). This erosion can be exacerbated by waves from boat traffic.

Sedimentation and erosion are major structuring forces on floodplain ecosystems, since they determine overall distribution of ecosystems on the floodplain. Sedimentation builds up landforms and erosion takes them away to be redeposited elsewhere. Large areas of the floodplain can be eroded and become part of the river channel as the river moves laterally across the floodplain. To a large extent, location and height of sediment deposits determine which ecosystems develop, and where.

Flooding affects the ecology of the floodplain in many ways (Table 4). Inundation as a disturbance to forest stands affects tree establishment and growth. It inhibits establishment of trees sensitive to inundation, such as conifers, and likely affects the growth rate of conifers that do establish in frequently flooded areas. Sitka spruce, the most abundant conifer on the floodplain, is one of the most tolerant conifers to flooding, after redcedar (Peterson et al. 1997). However, Beaudry and Hogan (1990) have shown that there is a clear negative relationship between flooding depth/duration and Sitka spruce growth.

Table 4: Flooding and sedimentation factors that affect vegetation on alluvial floodplains (McLennan 1995a, Roberts 2004).

Flooding	Process	Sedimentation	Process
Frequency	Number of floods per year or years between floods	Depth	Influences plant survival and resprouting ability
Duration	Length of inundation in event	Mineralogy	Chemical composition of sediments affects plant nutrition
Seasonality	Inundation during growing season or not	Texture	Influences water and nutrient holding capacity and drainage speed
Velocity	Water speed influences the amount of physical damage and erosion		

Much research has been conducted on effects of flooding on tree species establishment and successional development (e.g. Nanson and Beach 1977, Walker et al. 1986, Scott et al. 1996, Dykaar and Wigington 2000), but dynamics of the shrub, herb, and moss layers have been less studied (Roberts 2004). Herb and moss layers usually become more developed as ecosystems become flooded less frequently (Banner et al. 1993, MacKenzie and Moran 2004), but this could also result from changes in overstory composition or landform age.

Physical damage to plants can occur from water or from debris carried by water. Scars are common on trees impacted by floating debris (Gottesfeld 1996). The effect of physical damage to floodplain vegetation is not known, but is not likely to be a major structuring force.

6.6.3 Wind

Wind disturbance, although not widespread, does occur on the floodplain. Acer Resource Consulting (2000) documented a windthrow area in a 45-year-old cottonwood – red alder stand on an island complex 26 kilometres west of Terrace. The wind event was a summer storm that affected about 30% of stems, which were either uprooted or snapped 4 to 8 metres from the ground. The size of the area was not given but appears to be approximately 2 hectares. These blowdown events are likely to occur in the fall or winter and are probably caused by cyclonic storms originating in the Gulf of Alaska or strong katabatic (outflow) winds (Dorner and Wong 2002).

6.6.4 Insects

The poplar and willow borer, an exotic European weevil, has been present in the Terrace area since at least 1965 (Harris and Coppel 1967). Stems between 2 and 8 centimetres in diameter are most prone to attack. The larvae cause the most damage by boring into the stem, severely weakening it (Garbutt and Harris 1994). Death of attacked stems often occurs because of girdling, breakage, or disease facilitated by the wounds caused by the weevil (Broberg et al. 2002). Vole collars have been noted to protect poplar and willow borer from predation and increased their survival during the adult stage (K. White, personal communication 2004). Damage by poplar and willow borer to Scott Paper's cottonwood plantations in other parts of coastal BC has been insignificant to date (K. Stenerson, personal communication 2004). It is not known how important the poplar and willow borer has been in the dynamics of the low bench Cottonwood – Willow ecosystem, although there is no evidence that this pest is causing extinction of willow species or populations (Broberg et al. 2001).

Spruce weevil is the most important pest of spruce regeneration in BC. It is most serious in pure spruce plantations, such as those of the Kitimat River valley. It attacks the leaders of healthy young trees, and results in in multiple or crooked stems, general bushiness, and loss of height. Control is best attained through integrated pest management strategies such as planting mixed species and retaining overstory deciduous trees (Turnquist and Alfaro 1996). The weevil is generally not a serious problem in stands under natural dynamics or when there is an overstory present (K. White, personal communication 2004).

The northern tent caterpillar is a common defoliator of many deciduous tree and shrub species. Outbreaks of this pest have been recorded on the lower Skeena River and other local rivers in 1969-73, 1981-83, and 1989-92 (Garbutt and Wood 1993). These outbreaks resulted in light to moderate defoliation. Severe infestations may result in significant damage through loss of growth and branch dieback. Attacked trees are more susceptible to secondary effects including fungal infection and the environmental stresses of drought or frost (Garbutt and Wood 1993).

6.6.5 Diseases

The primarily deciduous forests of the Skeena River floodplain do not have major disease problems at present. Poplar leaf and shoot blight has been causing some mortality of cottonwood trees in the Hazelton area, but is not known to be a problem further west (A. Woods, personal communication 2004). Cottonwood can be attacked by the leaf rust *Melamspora occidentalis*, which is known to occur in the area. Repeated severe attacks by *Melamspora* rust can reduce growth and yield (Callan 1998).

6.7 Coarse Woody Debris

Coarse woody debris is recognized as playing an essential role in forest ecosystem function (Harmon et al. 1986). A body of literature about the role of CWD in forest ecology is developing (e.g. Laudenslayer et al. 2002). In the CWHvm subzone, there is a mean volume of 554 m^3/ha (range 13-1788) and mean mass of 19 kg/m^2 (range 2-40) of CWD. This is one of the highest levels of CWD measured in BC, only exceeded by that in the neighbouring CWHvh. This amount of CWD is likely a result of the high productivity of CWH stands (Feller 2003). It is not known whether any of Feller's plots were located on floodplain sites, but as floodplains are among the most productive sites in the CWH, large amounts of CWD could be expected to occur on these sites. Lower amounts of CWD would occur on younger floodplains where there has been less time to build up CWD deposits.

Coarse woody debris plays a role in maintaining biodiversity in forests by providing habitat for many plants, especially lichens, liverworts, and mycotrophic herbs (Feller 2003). Specific data on the importance of CWD in coastal floodplain forests is not readily available, but in deciduous forests CWD can be important in maintaining the diversity of the understory plant community. This is due to habitat differences between CWD and the surrounding forest floor (Lee and Sturgess 2001). In one study of old-growth forests in BC, 23% of the recorded 243 vascular plant species were recorded only on CWD, and for lichens and liverworts the corresponding figures were 71% of 59 species and 25% of 26 species, respectively (Song 1997 *in* Feller 2003).

Coarse woody debris is known to be an important habitat feature for many animal species but quantitative studies are only available for a few species in BC (Feller 2003). Many vertebrate species, especially amphibians, show a positive relationship to the presence of CWD (Bunnell et al. 1999).

Tree regeneration is affected by CWD abundance. In riparian forests in Oregon and Washington, 52 to 90% of all conifer regeneration occurs on CWD, even though CWD represents a much smaller percentage of the available substrate (Beach and Halpern 2002, Naiman et al. 2002). Coarse woody debris is thought to provide elevated microsites above competing vegetation (Harmon and Franklin 1989). Beach and Halpern (2001) found that 85% of Sitka spruce regeneration in riparian areas occurred in areas with less than 10% shrub cover. Most of the shrub cover was salmonberry, which is a dominant species on the Skeena. Harvesting of conifers from floodplains and replacement with deciduous trees has reduced conifers for production of CWD in future. This could affect long-term regeneration dynamics of these forests (Peterson et al. 1997). Proximity to seed source is also an important factor in regeneration in riparian forests (Beach and Halpern 2001). Without conifers on site to produce seeds, conifer regeneration will be less successful.

Coarse woody debris can enter sites with floods, so can be present in some young stands that might otherwise not have CWD. This occurs mainly near the main channel, and can provide conditions for regeneration.

The amount of CWD tends to be lower in managed forests than in unmanaged forests, with studies showing that CWD will decrease from 30 to 40% of wood volume to about 1% after several rotations (Bunnell et al. 1999). In order to maintain CWD within the forested landscape, measures need to be taken to ensure its continued recruitment in managed forests (Harmon 2002).

7.0 Rare Plants, Wildlife, Fish and Ecosystems

7.1 Rare Element Ranking Methods

The BC Conservation Data Centre uses a standardized methodology to rank species according to their commonness or rarity. Each species is ranked using the system developed by NatureServe in the United States at two levels:

- Global (G).
- Provincial or Subnational (S).

The global rank is based on the element's status throughout its entire range while the provincial rank is based on its status in BC. The global rank is established by a botanist assigned to the element by NatureServe. The provincial rank is established by botanists at the CDC.

The CDC compiles lists of species based on the ranks. These lists are designed to simplify the interpretation of the ranks and are used in this report. The Red list contains species that are legally designated as Endangered or Threatened under the Wildlife Act (Province of BC 2004) are extirpated or are candidates for such designation. The Blue list contains species not immediately threatened but that are of concern because of characteristics that make them particularly sensitive to human activities or natural events. The Yellow list contains all species not on the Red or Blue lists (CDC 2002). Yellow-listed species may be uncommon or common, or increasing or decreasing in abundance.

7.2 Plants

There are 19 vascular plant species on the CDC Red and Blue lists for the Kalum FD (Table 5). Most of the species are not likely to be found on the floodplain due to the lack of appropriate habitat requirements (e.g. alpine tundra). Two listed species have been found near the study area: white adder's mouth orchid (*Malaxis brachypoda*) and dune bentgrass (*Agrostis pallens*). The orchid could occur in the study area as it grows in moist forests and stream banks. However, all local collections of the orchid and the bentgrass were made on rocky outcrops or ledges, a habitat not found within the study area. Several other listed species could occur on the floodplain in appropriate habitats (Table 5).

Table 5: Listed vascular plant species for the Kalum FD (BC Ministries of Sustainable Resource Management and Water, Land and Air Protection 2004) and other potentially rarely occurring species.

Scientific Name	Common Name	BC Status	Habitat	Likely in Study Area
Agrostis pallens	Dune bentgrass	Blue	Dry coastal habitats	?
Botrychium pedunculosum	Stalked moonwort	Red	Meadows - found at Kleanza Creek	?
Callitriche heterophylla ssp. *heterophylla*	Two-edged water-starwort	Blue	Aquatic habitats	Perhaps
Carex rostrata	Swollen beaked sedge	Blue	Peat Bogs	No
Draba cinerea	Gray-leaved draba	Blue	Dry meadows and cliffs at high elevations	No
Draba lonchocarpa var. *thompsonii*	Lance-fruited draba	Blue	Meadows, cliffs and scree in the alpine	No
Draba lonchocarpa var. *vestita*	Lance-fruited draba	Blue	Meadows, cliffs and scree in the alpine	No
Dryopteris cristata	Crested wood fern	Blue	Wet swamps and meadows	No
Eleocharis kamtschatica	Kamchatka spike-rush	Blue	Marshes, wet meadows and bogs	?
Epilobium hornemannii ssp. *behringianum*	Hornemann's willowherb	Blue	River banks and wet rocky cliffs	Perhaps
Epilobium leptocarpum	Small-fruited willowherb	Blue	Moist meadows and stream banks	Perhaps
Eutrema edwardsii	Edwards wallflower	Blue	Dry talus slopes	No
Juncus regelii	Regel's rush	Blue	Wet stream banks and marshes	Perhaps
Juncus stygius	Bog rush	Blue	Pond margins and bogs	Perhaps
Malaxis brachypoda	White adder's-mouth orchid	Blue	Moist forests and stream banks	Perhaps
Malaxis paludosa	Bog adder's-mouth orchid	Blue	Bogs and muskeg	No
Pedicularis parviflora ssp. *parviflora*	Small-flowered lousewort	Blue	Wet meadows, fens and bogs	No
Poa eminens	Eminent bluegrass	Blue	Gravelly beaches	No
Polemonium boreale	Northern Jacob's-ladder	Blue	Meadows and rock outcrops	No
Polystichum setigerum	Alaska holly fern	Red	Rock outcrops and lava	No

In addition to the listed vascular plants, a number of rare mosses are known in the area (Table 6). There are no known rare liverworts in the area. Little is known about the status of lichens in the area, but one of Canada's rarest lichens has been found on large old cottonwood trees near Terrace and thus is a strong candidate to be found on the Skeena Islands. Despite the presence of large, old trees, the active disturbance regime of the floodplain forests could be less conducive to establishment of rare lichens and bryophytes than ancient forests which experience very little disturbance (Goward and Pojar 1998).

Table 6: Rare moss and lichen species found in the general area of the Skeena River floodplain (Ryan 1996, Selva 2003, BC Ministries of Sustainable Resource Management and Water, Land and Air Protection 2004).

Scientific Name	Common Name	BC Status	Notes
Mosses			
Bryhnia hultenii		Red	Inver Creek on log
Entodon concinnus		Blue	Kwinitsa River on alder trunks
Isopterygiopsis muelleriana		Red	Inver Creek on shaded cliff shelf
Orthotrichum rivulare		Red	Thornhill Creek on rock and roots on creek bank
Pleuroziopsis ruthenica		Blue	Exchamsiks River Park in alluvial spruce forests
Lichens			
Sclerophora peronella	Frosted glass-whiskers	One known location	Kitsumkalum Lake Park on large cottonwood tree

7.3 Wildlife

Riparian and floodplain forests are recognized as important for maintenance of biodiversity, largely due to the presence of deciduous tree species (Bunnell et al. 2002). Deciduous trees are used by wildlife for cavity nesting, and they host abundant insects (Bunnell et al. 1999, Bunnell et al. 2002).

In a regional context the Skeena River floodplain is thought to be important to wildlife in four ways:

- As a major corridor between the interior and the coast.
- For seasonal migrations between high and low elevations (i.e. wintering habitat).
- As a stopover during long distance migrations.
- For providing old deciduous tree habitats for denning, nesting, and foraging (Burton 1998, A. Hetherington, communication 2004).

The potential impacts of hardwood management on wildlife in BC have been investigated (Enns et al. 1993), however, there is a lack of inventory and research information for many areas of the province including the Skeena River floodplain. The lack of knowledge about wildlife use of this area is exemplified by the recent find of a northern goshawk nest in a cottonwood tree on the Skeena Islands. This species, identified under the Forest and Range Practices Act (Province of BC 2005) was not thought to use forests of this type in the area (B. Pollard, personal communication 2004).

Forestry activities generally convert old-growth or mature successional stage forests to earlier stage forests. On the Skeena River floodplain this conversion has been extensive, with most of the area now comprised of young age class forests. The wildlife groups most affected are those dependent on large old trees for habitat. The birds that use these trees for nesting habitat include bald eagle, pileated woodpecker, northern flicker, and other primary and secondary cavity nesting species (Enns et al. 1993, Peterson et al. 1996). Other wildlife groups that may have been affected are small mammals such as *Myotis* bats which use large old cottonwood trees as maternity colonies, and ungulates, which use conifer-dominated forests for shelter during periods of heavy snow accumulation and for calving (Enns et al. 1993).

There are twelve wildlife species on the CDC Red and Blue lists for the Kalum FD: 6 birds, 4 mammals, 1 amphibian, and 1 butterfly (Table 7) (BC Ministries of Sustainable Resource Management and Water, Land and Air Protection 2004). The importance of the ecosystems in the study area for some of the species is not well known; however, several of the listed species do not occur in the area or use the area to any degree. The short-eared owl, peregrine falcon, Swainson's hawk, and gyrfalcon tend to hunt over open terrain so are not likely to use the study area heavily for hunting or nesting (Acer Resource Consulting 2000). Marbled murrelets use old conifer trees for nesting, but as much of this habitat type has been harvested, they may no longer use the study area. The afranius duskywing butterfly uses a wide range of habitats including riparian areas, and coniferous and deciduous forests (NatureServe 2004), but its status in the study area is not known.

Table 7: Listed wildlife species for the Kalum FD (BC Ministries of Sustainable Resource Management and Water, Land and Air Protection 2004).

Scientific Name	Common Name	BC Status	Identified Wildlife	Likely in study area
Ascaphus truei	Coastal Tailed Frog	Blue	Yes	No
Asio flammeus	Short-eared Owl	Blue	Yes	No
Brachyramphus marmoratus	Marbled Murrelet	Red	Yes	?
Buteo swainsoni	Swainson's Hawk	Red		No
Erynnis afranius	Afranius Duskywing	Red		?
Falco peregrinus ssp *anatum*	Peregrine Falcon, *anatum* subspecies	Red		No
Falco rusticolus	Gyrfalcon	Blue		No
Gulo gulo ssp *luscus*	Wolverine, *luscus* subspecies	Blue	Yes	Not high use
Martes pennanti	Fisher	Red		Yes
Otus kennicottii ssp *kennicottii*	Western Screech-Owl, *kennicotii* subspecies	Blue		No
Rangifer tarandus	Caribou (northern mountain population)	Blue	Yes	No
Ursus arctos	Grizzly Bear	Blue	Yes	Yes

Fisher may occur in the area. Maternal den sites for fisher have been found exclusively in large declining cottonwood trees, with winter resting sites occurring in large CWD, large spruce trees with spruce broom rust, and large declining cottonwood (Weir 2003). The availability of denning and resting sites may be a population-limiting factor. Most habitat use is associated with mature and old forest structural stages. Riparian and riparian-associated habitats are also critical (Weir 2003, BC Ministry of Forests 1997). These habitat features are now less common in the study area due to past harvesting.

The wolverine is a wide-ranging species that hunts opportunistically; details of its use in the study area are not known.

The floodplain is well used by black and grizzly bears - in the spring for forage, in the summer for berries and in the late summer and fall for salmon and berries. Day beds are located in damp shady hollows in the forest (Acer Resource Consulting 2000, A. de Groot, personal observation 2004). Forestry activities may increase forage availability, at least temporarily, as young seral stands often have a high shrub or herb component (Peterson et al. 1996), but this will depend on the shrub species present. In early spring, black bears have been observed feeding on cottonwood buds high in the forest canopy (B. Fuhr, personal communication 2004), and grizzly bears are known to hunt moose calves on the floodplain (Acer Resource Consulting 2000). There is some evidence that grizzly bear habitat use depends more on the presence or absence of active roads than on the seral condition of the forest (Wielgus and Vernier 2003). If this is the case harvesting may have little effect on grizzly bears, provided harvesting maintains other habitat features, because few new permanent roads are likely to be built in the study area.

The Red- and Blue-listed species are not the only species requiring special management consideration on the floodplain. Two Yellow-listed species of concern in the area are bald eagle and moose. Bald eagles use the large upper branches and forks of old cottonwood trees near the water for nesting and perching sites (Acer Resource Consulting 2000). Allowing cottonwood forests along waterways to mature will provide habitat for this species (Madrone 1997).

The Skeena Islands provide critical winter range for moose. The area is within the moose winter range identified by the Kalum LRMP. The floodplain has recently been proposed as "primary moose winter range" within the larger zone to be designated as Ungulate Winter Range. Important factors needed for moose winter range are: browse availability, snow interception, security cover and thermal cover (Keim and Vanderstar 2004). Moose appear to use early successional low bench sites, which contain preferred browse species such as willows and red-osier dogwood, more heavily than mid-bench cottonwood-dominated sites. High bench, conifer-dominated patches are used for bedding and snow avoidance (Acer Resource Consulting 2000). An increase in early seral stages due to logging may increase forage for moose and deer (Enns et al. 1993), but may be underutilized if suitable bedding areas are not available nearby.

Forest management plans within primary moose winter range must contain strategies to:

- Maintain and enhance winter forage for moose.
- Maintain and enhance security cover for wintering moose.
- Maintain and enhance thermal cover for wintering moose.
- Limit road development.
- Limit winter access for recreational and other users (Keim and Vanderstar 2004).

7.4 Fish

The Skeena River is the second most important salmon-producing river in BC with annual escapements of nearly 2 million fish. The study area is used by many fish including all five species of Pacific salmon, Dolly Varden, steelhead, and cutthroat. Four salmon species - chum, pink, chinook, and coho - spawn on the lower Skeena. Pink spawners are the most abundant (Bustard 1991, Bustard 1995). Most of the adult salmon using the Skeena migrate through the study area.

The extensive network of backchannels and wetlands on the Skeena River floodplain downstream of Terrace provides important rearing habitat for juvenile salmonids as well as for migrating adult and juvenile salmon (Bustard 1991, Bustard 1993). Many backchannels were blocked off from the mainstem of the river when the railway and highway were constructed, although some movement of juvenile fish through the riprap is possible (Bustard 1984, Bustard 1991).

Logjams are an important habitat feature for juvenile salmonids. They are used as rearing habitat and improve habitat quality by buffering flow into adjacent backchannels. Logjams are especially important over the winter to late summer, when they are used as rearing habitat by juvenile chinook, steelhead, and coho (Bustard 1991).

Four fish species Blue-listed by the CDC occur within the Kalum FD (Table 8) and three are known to occur in the study area (Bustard 1991).

Table 8: Listed fish species for the Kalum FD (BC Ministries of Sustainable Resource Management and Water, Land and Air Protection 2004).

Scientific Name	Common Name	BC Status	Identified Wildlife	Likely in Study area
Oncorhynchus clarki ssp *clarki*	Cutthroat Trout, *clarki* subspecies	Blue	No	Yes
Salvelinus confluentus	Bull Trout	Blue	No	No
Salvelinus malma	Dolly Varden	Blue	No	Yes
Thaleichthys pacificus	Eulachon	Blue	No	Yes

7.5 Ecosystems

The dominant ecological communities on the Skeena floodplain are listed by the CDC. The high bench Sitka spruce – salmonberry ecological community (CWHws1/07; CWHvm1/09) is Red-listed, and the middle bench Black cottonwood – red-osier dogwood ecological community (CWHws1/08, CWHvm1/10) is Blue-listed (BC Ministries of Sustainable Resource Management and Water, Land and Air Protection 2004). These ecosystems are rare because they occupy a small proportion of the landscape and are located in prime areas for development in the flat valley bottom.

Only a small portion of the original Sitka spruce ecosystem remains unharvested on the floodplain. Some of this ecosystem occurs in the Gitnadoix River and Exchamsiks River Protected areas, but much is unprotected. The amount of primary succession middle bench forest remaining is not known due to difficulties in differentiating these stands from disturbed stands on aerial photographs.

Based on fieldwork in the CWHvm1 and CWHvh2 in the North Coast FD, Ronalds and McLennan (2002) recommended that the high bench ecosystem be downgraded from Red to Blue, and that the middle bench be upgraded from Blue to Red. These recommendations were based on the number of occurrences (called "element occurrences" by the CDC) in structural stage 7 (old forest) inventoried within the North Coast FD, and did not consider other factors that are considered when ranking rare ecosystems, such as long and short-term trends, condition, threats, number of protected occurrences, and intrinsic vulnerability (CDC 2002). Individual element occurrences are often ranked to determine their relative conservation value. These ranks are based on the present status of that occurrence. Ranking is based on three factors: size, condition, and landscape context, each with several components.

Other rare ecosystems may occur on the Skeena floodplain, but they may be undescribed or may not be formally recognized ecological units. Madrone (1997) described a rare ostrich fern – water parsley plant community found in poorly drained floodplain depressions. The Blue-listed Sitka spruce – Pacific Crabapple ecological community (CWHvh2/19) described only from maritime areas, has been reported to occur near the mouth of the Gitnadoix River (de Groot and Bartemucci 2003).

A key factor for ranking the ecosystem element occurrences on the Skeena River floodplain is the structural and successional stage of the ecosystem.[1] Many of the other ranking factors listed above are similar among all element occurrences on the floodplain. Stand structure and successional stage are important to the overall functioning of the floodplain landscape and its value for wildlife and fish. For example, the large old trees that provide long-term stability for logjams (Naiman et al. 2002) and bedding and denning sites for wildlife are mostly absent in early successional stages.

The ecosystem dynamics described above present interesting ecosystem conservation challenges. While the areal extent of the floodplain ecosystems may not change over time, their location may shift due to erosional and depositional processes. Low bench ecosystems, which are not currently listed, may eventually become listed middle and high bench ecosystems (McKenzie and Moran 2004). The floodplain turnover rate is important in this respect. If the floodplain turnover rate is slower than forest development or forest turnover rates, flooding will have less influence on overall ecosystem structure than if floodplain turnover rate is faster than the forest turnover rate (Richards et al. 2002). Managing the entire landscape unit to maintain a representation of each of these ecosystems, with the high bench in the desired old growth condition, requires land management planning on a long time frame to allow for recruitment of each successional stage (Burton 2000).

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1. Previously the CDC had included the descriptor of the mature plant community of the ecosystem of interest - often this was structural stage 7 (old forest). This was often interpreted to mean that occurrences in a younger structural stage or an earlier successional stage were not valuable, and therefore did not need special management considerations. However, due to the rarity of these sites for some plant communities, younger structural stages are valuable for conservation, as they will allow the recruitment needed to represent older stages over time. The CDC has now removed the structure and successional stage considerations from their ranking so that confusion does not arise around the meaning of these factors.

8.0 Comparison to other Floodplain Ecosystems

The Skeena River is the 46th largest river flowing into the ocean (i.e. not a tributary to another river) in the world (Leopold 1994), and is one of a small number of large river ecosystems on the west coast of North America. Others include the Columbia (18th), Fraser (30th), Stikine (48th), and Nass (69th). Smaller rivers draining this coastline include the Chilkat, Dean, Homathko, Khutzeymateen, Kimsquit, Kingcome, Kitimat, Kitlope, Klinaklini, Squamish, Taku, and Tatshenshini-Alsek. The watersheds of these smaller rivers lie closer to the coast and thus tend to have different hydrological dynamics. These dynamics include fall flooding resulting from intense storms and rain-on-snow events (McLennan 1995a). These floods are usually much shorter in duration than the spring/summer snowmelt floods, which result in long slow peaks, and tend to produce high bench ecosystems rather than middle bench ecosystems (McLennan 1995a). Observations of Davies and Gottesfeld (1986) substantiate this as they note that the Nass River floodplain tends to have older surfaces that are more stable, and fewer highly productive cottonwood sites (i.e. middle bench) than the Skeena River floodplain.

Floodplains on the outer coast of BC and those inland differ in the dominant tree species in early successional stages. On the Skeena and other floodplains further inland, cottonwood is usually the dominant tree species. Red alder is subdominant or absent. On coastal floodplains, cottonwood is mostly absent and red alder dominants early successional stages (Clement 1985).

There is little literature on the ecology of other major floodplains on the west coast of North America, especially in relation to forest dynamics. The closest large floodplain to the Skeena is that of the Nass River. The climate of the Nass River floodplain is less temperate, with colder winters and colder wetter summers. The Nass River floodplain may be more stable, with older surfaces and finer sediments. The Nass has a less well-defined annual peak flow but maintains high waters for a longer period, persisting for nearly the entire growing season (Davies and Gottesfeld 1986), while the Skeena has an earlier and sharper peak, and has a more defined low stage in late summer. Fall floods are more common on the Nass. The four largest recorded floods on the Nass all occurred in October (Water Survey Canada 2004). These hydrological dynamics may be due to the more coastal characteristics of the Nass watershed and its higher snowpack that persists later into the summer. The long periods with a high water table mean that water table height is more of a limiting factor to tree growth on the Nass River. Shrub-dominated plant communities are more common on the Nass floodplain. Areas for good cottonwood growth are smaller on the Nass since cottonwood prefers active, well-drained sites, which are less common on the Nass floodplain (Davies and Gottesfeld 1986). Redcedar does not occur on the floodplain of the Nass, thus successional dynamics differ from those of the Skeena River floodplain.

The floodplains of the lower Stikine River and its tributary, the Iskut River, are some of the more active on the west coast. These braided rivers have areas with constantly changing gravel bars, and have active fans extending into the floodplain. The active floodplain of the Stikine is approximately 6 kilometres wide near the border with Alaska, and contains areas with large productive wetlands near the confluence of the Stikine and Iskut Rivers (Clement 1992). There has been little development along the Stikine, and the flow regime has seen little alteration to date. Successional patterns of the Stikine and Skeena floodplains are similar. The climax is an open stand dominated by Sitka spruce and devil's club (Clement 1992, Banner et al. 1993). In the Stikine and Taku River valleys wetlands and shrublands may be more common than on the Skeena, with 39% of the land cover being non-forested. Several bird species that are rarely seen in the area are common in the riparian forests of the Stikine River, including the warbling vireo, American redstart, and western tanager (Nowacki et al. 2001).

The Tatshenshini-Alsek and Chilkat Rivers also have wide braided channels. Cottonwood, willows, and red alder dominate much of the floodplain vegetation. Spruce and hemlock forests occur on the more stable sites (Nowacki et al. 2001). These areas are still experiencing uplift from isostatic rebound after glacial melting. Aeolian deposits can be found on these northern rivers, formed as strong outflow winds carry exposed fine riverbank sediments downstream (Nowacki et al. 2001). Many glacial outburst floods, or *jökulhlaups*, have occurred on the Tatshenshini-Alsek River, with the last recorded flood occurring less than 150 years ago (Clague and Rampton 1982). The Skeena and Nass have more of an anastomosing pattern, consisting of multiple channels around relatively stable forested islands, in contrast to these rivers, which are braided with many gravel bars.

The floodplain dynamics of the lower Columbia River have been greatly altered by a series of dams along the river, and by diking and dredging along the lower river. The spring flooding regime has been largely eliminated, affecting the forests and wetlands of the floodplain along the lower river (Oregon Wetlands Joint Venture 1994). The extent of alteration of this landscape makes comparisons with the Skeena difficult.

The lower Fraser River has a similar anastomosing pattern to the lower Skeena River, and much of the area contains cottonwood plantations. There is little information available, however, on the dynamics of this area.

The Kitimat River, the next drainage south of the Skeena River at Terrace, was widely thought to have suffered logging-related habitat degradation in the late 1980's, leading to declining fish stocks. Riparian areas were extensively logged and the overall forest harvesting rate increased substantially in 1967. Karanka (1993) looked at the effects of this harvesting on the stability of the river channel and the possible causes of changes in channel stability. Flooding dynamics were found to be the cause of fish stock declines; specifically, large floods in 1974, 1976, and 1978. Channel enlargement also occurred during these floods. Direct links to forest harvesting were not found, with large increases in sediment supply to the river thought to be causing channel destabilization (Karanka 1993). The cause of the changes in sediment supply was not investigated. Changes in the coarse woody debris supply due to riparian logging may have also played a role in side channel instability (Karanka 1993). These findings, though not comparable to the Skeena River, highlight the complexity of floodplain dynamics and the interaction between components.

9.0 Forest Management and Silviculture

9.1 Harvesting and Silviculture History

Commercial forest harvesting began on the Skeena River floodplain in the 1890's when firewood was required for stoking paddle wheelers travelling up the river. More floodplain forests were cleared for the railway right-of-way, which opened in 1914, and for the highway. Selective logging of spruce started in the 1940's. Clearcut logging began in the late 1950's. By the late 1960's harvesting of Sitka spruce and redcedar stands was mostly completed (Gottesfeld et al. 2002).

Some unharvested stands of coniferous-dominated floodplain forest remain scattered along the Skeena River (Haeussler 1998, Burton 2000). Some conifer-dominated areas were not clearcut so residual conifers may occur in the secondary deciduous stands that regenerated on harvested sites. Primary succession cottonwood-dominated middle bench stands are more common than primary conifer-dominated stands. New cottonwood stands continue to develop through primary succession on young sites on the floodplain. Both primary and secondary cottonwood stands have been harvested in recent years on the floodplain, as have some primary coniferous stands.

Attempts to establish pure conifer stands on harvested floodplain sites have generally failed. Thus most harvested sites are dominated by cottonwood or red alder (Davies and Gottesfeld 1986, Beaudry et al. 1990). Regular flooding, intense shrub competition, and heavy browsing of planted seedlings by voles and other small mammals (Beaudry et al. 1990, Ministry of Forests 1988) have impeded survival and growth.

McLennan (1995b) describes three strategies for forest regeneration on floodplains:

- Cluster planting with reduced stocking.
- Establishment of conifers under a nurse canopy of hardwoods.
- Planting or natural regeneration of hardwoods.

Each of these approaches is designed for post-clearcut harvesting. Each approach has limitations and conditions for its appropriate use differ.

Cluster planting is designed to produce a crop of conifer trees while maintaining forage values on the site over the length of the rotation. The nurse canopy approach mimics natural succession of shade-tolerant conifers under faster-growing deciduous species. Management for hardwoods utilizes the fast growth of these species to produce fibre. All three methods have been or are being used in the study area with varying success.

The high density of brush found on fluvial sites on the Skeena floodplain is a common feature of floodplains along the Pacific north coast. Problems establishing conifers on these sites have been reported from southeast Alaska where these sites present severe silvicultural challenges (Harris and Farr 1974), and from many locations in coastal BC (Banner et al. 1993, McLennan 1995b, Peterson et al. 1997). Forest management on floodplain sites in other areas of BC often focuses on cottonwood and some red alder, because these species establish more readily on brushy, flood prone sites. Planting spot choice is important, especially for conifers. A small difference in height of the planting spot can be critical for tree survival and growth (Beaudry and Hogan 1990).

A variety of site preparation methods, including blading, brushing, and herbicide application, has been used on alluvial sites. Soil disturbance facilitates the establishment of red alder, which competes with conifers (Peterson et al. 1997). Repeated treatments are often needed in order to successfully establish conifer plantations. The use of herbicides on alluvial sites can be controversial because of the effects on adjacent waterways and on non-crop forage species (Hamilton et al. 1991, Peterson et al. 1997), and the expense of repeated treatments of any sort can be prohibitive.

9.2 Research History

Several research trials have been conducted on alluvial sites in the study area to determine the best methods to re-establish conifer stands.

A 5-year trial begun in 1984 near the Exchamsiks River used blade scarification combined with grasses and legumes seeded either singly or in combination to control competing vegetation in a Sitka spruce plantation (Coates et al. 1993). Although these treatments had some success in controlling competing vegetation, Sitka spruce seedling growth was best in the scarified but unseeded control plots.

A subsequent trial at Salvus near the Kasiks River was initiated in 1986 to test a variety of silvicultural treatments aimed at replacing secondary red alder/cottonwood stands with coniferous plantations (Ministry of Forests and Lands 1988). The treatments, used either singly or in combination, included blading, burning, girdling, felling and bucking, grass seeding, broadcast spray with glyphosate, and hack and squirt using glyphosate. These treatments all failed to establish coniferous plantations because of vole damage to redcedar seedlings and the vigorous growth of competing vegetation (Inselberg et al. 1990, Ministry of Forests 1990, Macadam and Blackwell 1994). The trial was not maintained after 1992.

A trial initiated in 1993 used a shelterwood system with cottonwood as a nurse crop to help establish conifers on several rehabilitated floodplain sites following recommendations of McLennan and Klinka (1990). Secondary treatments included use of vole collars, brush mats and manual brushing. Cottonwood mortality was high on most sites, as a result of vole and moose browse damage and rooting failure. Conifer survival was higher than cottonwood survival, and browsing was the main cause of mortality (Oikos Ecological Services 1996). Survival of cottonwood and redcedar has been variable in this trial (R. Meredith, communication 2004).

A research program into floodplain stability, island longevity, and flood hazard classification was initiated in 1986 as flooding and the geomorphological dynamics of the floodplain are important structuring influences on the forests (Beaudry et al. 1990, Schwab et al. 2002). The floodplain stability research used a series of five sets of aerial photographs from 1947 to 1987 and had the following objectives:

- Documentation of history of island development through deposition and erosion over 40 years.
- Evaluation of longevity of islands through determination of the rate of channel movement.
- Development of a classification that identifies relatively stable areas suitable for silvicultural investment.

Four sets of maps were produced. Many of the results have been discussed previously in this report.

The objectives of the flood hazard classification were:

- Description of the physical flooding process (frequency, duration, and process).
- Determination of the effects of flooding on Sitka spruce seedling growth.
- Design of a classification/mapping scheme that could highlight areas with high flooding hazard.

The flood hazard classification scheme identified three factors to consider:

- Whether linear depressions are open or closed to the main channel, allowing drainage.
- Distance from river flow.
- Hummocks and elevated areas (Beaudry and Hogan 1990).

9.3 Present Practices

Recently forest managers have attempted to mimic natural disturbance regimes or natural processes when designing forest management practices (Haeussler and Kneeshaw 2003). A critical assumption of the natural disturbance paradigm is that silvicultural practices such as clearcutting and site preparation are sufficiently similar to natural disturbances such as wildfire that they can at least partially replace them. In the case of floodplain ecosystems, it is difficult to argue that logging either emulates or can replace flooding. However, a natural disturbance-based approach to forest management requires that managers recognize the importance of flooding to ecosystem dynamics and work within the constraints that flooding imposes on the system.

Rare ecosystems such as floodplains typically have different disturbance regimes than those of the surrounding landscape. It is therefore inappropriate to base ecosystem management on the average disturbance regime for the region. For example, past silvicultural efforts have focussed on establishing fully stocked open-grown conifer plantations on the floodplain. These attempts failed to a large degree because conifers planted at regular intervals on the forest floor (rather than on elevated microsites such as levees and decaying wood) could not withstand the extended periods of flooding frequently experienced on the floodplain, and the fully open conditions created extreme competition from brush (Beaudry et al. 1990, McLennan 1995b).

Silviculture with flood tolerant and fast growing deciduous species, mostly cottonwood, is now being practiced on the floodplain. Existing conifer regeneration in these cottonwood blocks is being retained to provide structural diversity to the stands and to provide future coarse woody debris. An assessment of the potential cottonwood supply from the Skeena Islands found that there was excellent potential for cottonwood management but that many sites had significant access limitations due to their location in mid-channel (Benzer and Viveiros 1999).

9.4 Cottonwood Management

Cottonwood management is recognized as a cost-effective alternative to conifer management on alluvial sites in coastal BC (Peterson et al. 1996).

Trials of hybrid cottonwood were established by Columbia Cellulose in the Skeena River area in the late 1950's and early 1960's. The success of these trials was mixed for a variety of reasons, including detrimental flood and vole damage (Davies and Gottesfeld 1986).

Managers prefer Populus hybrids to native black cottonwood because of better rooting of cuttings, disease resistance, and hybrid vigour (Stettler et al. 1996). The BC Ministry of Forests has a list of preferred Populus trichocarpa x P. deltoides clones that are well adapted to northern areas such as the Skeena (M. Carlson, personal communication 2004).

Cottonwood is usually planted as long whips (1.0 to 2.0 metres long) or short cuttings (0.2 to 0.5 metres long). Whips are preferred where competing vegetation is likely to be a problem so that growth can be above the vegetation after one year. One-third of the total whip length must be in the ground so that there will be enough root mass to supply water to the growing plant, otherwise there will be dieback at the tip of the whip (M. Carlson, personal communication 2004), a problem that has occurred in some plantations in the Skeena River area (R. Meredith, personal communication 2004). Whips should be 1.5 centimetres in diameter at the base and have their buds above the surrounding vegetation. Vole collars are usually needed and brush control is also preferred (M. Carlson, personal communication 2004). For further details of cottonwood silviculture in British Columbia see Peterson et al. (1996) and McLennan and Mamias (1992).

Scott Paper manages cottonwood on TFL 43 and private lands in the lower Fraser Valley near Chilliwack. TFL 43 includes areas in three drainages: Fraser River at Chilliwack, Homathko River at the head of Bute Inlet, and Kingcome River on Kingcome Inlet. TFL 43 covers 10,106 hectares of which 6153 hectares are considered productive forest, and of this 3326 hectares are in the timber harvesting land base (Scott Paper 1999, Beedle 2000). The objective on TFL 43 is to achieve as short a rotation as possible (Scott Paper 1999). The primary harvesting system is clearcutting, because of the shade intolerant nature of cottonwood. Some wildlife or riparian zones are selectively or partially cut. All blocks are immediately planted with cottonwood or hybrid poplar using whips or cuttings. Natural regeneration by sprouting from cut stumps is common. Partially buried fragments left after harvesting may also be important for regeneration.

Peterson et al. (1996) describe three possible approaches to cottonwood management on alluvial sites:

- Intensive.
- Extensive.
- Mixed wood extensive.

The intensive management regime, sometimes called short rotation intensive culture, is practiced by Scott Paper on level terrain with easy access, such as that of the Fraser River area below Hope. This management regime uses hybrid poplar and a high level of inputs to produce a crop of 300 to 400 m^3/ha in 10 to12 years. Inputs on these intensively managed sites are aimed at maximizing tree growth and reducing vole damage using a combination of cultivation, mulches, herbicides, and fertilization. Management of competing vegetation is a key component of the regime in the first few years of crop establishment. Where lower intensity vegetation management is practiced, a longer rotation of 15 to 25 years produces 300 to 400 m^3/ha. Scott Paper also regularly prunes and spaces its intensively managed stands on the Fraser River (Scott Paper 1999, Thomas and Comeau 1998, Thomas et al. 2000).

Extensive management uses a minimum of inputs. Sites are usually planted with larger stock so that brush control is not needed. The crop rotation is usually 25 to 30 years with a yield of 250 to 450 m^3/ha (Thomas et al. 2000). This system is used by Scott Paper in the Homathko and Kingcome portions of TFL 43.

Mixed wood extensive management uses cottonwood as a nurse tree species with shade-tolerant conifers grown in the understory. When the cottonwood is harvested the conifers are released. The cottonwood trees suppress the brush, allowing conifers to become established without the aid of herbicides (McLennan and Klinka 1990, Peterson et al. 1996). The results of a mixed wood trial in the Skeena River area are discussed in Section 9.2 of this report. Presently in the area conifer regeneration is retained during cottonwood harvest operations but no additional conifers are planted.

The requirements for good cottonwood growing sites on the Skeena and Nass Rivers were investigated by Davies and Gottesfeld (1986). Aside from the presence of near continuous cover of cottonwood, they identified the following characteristics of good cottonwood growing sites:

Soil characteristics:

- Regosols, especially cumulic Regosols.
- Sandy to loamy texture.
- Near neutral pH in surface horizons (6.0 - 7.0).
- Moder or mull humus form.

Flood history:

- Evidence of repeated flooding.
- Flooding associated with active river flow.
- Deposition of silt to sand layers from flooding.

Vegetation factors:

- Favourable understory indicators: salmonberry, lady fern and red elderberry, along with enchanter's nightshade, and sweet-scented bedstraw.
- Unfavourable indicators: hardhack, bunchberry, huckleberry, and oakfern.

These conditions are similar to those indicated as optimal for cottonwood growth by Peterson et al. (1996).

Burton (1998) indicated that management for cottonwood production could be an appropriate use of floodplain areas, as long as other values such as wildlife trees, other wildlife habitat features, and water quality are taken into account. In the Homathko and Kingcome blocks of TFL 43, 56 and 40 percent, respectively, of the total productive forest area in each block does not contribute to the timber supply because of operability, environmentally sensitive areas, and riparian classifications, and will not be actively managed (Scott Paper 1999, Beedle 2000).

9.5 Forest Practices Code Guidelines

The BC Forest Practices Code establishes guidelines for biodiversity and riparian area management. Guidelines for relevant natural disturbance types are summarized here so that the present status of the Skeena Islands Landscape Unit as delineated by the Ministry of Sustainable Resource Management can be compared to the guidelines. These guidelines, although they have been replaced by a results-based system, are still in effect where new plans have yet to be approved. Note that guidelines for NDT1 and NDT2 were developed for upland forest landscapes and do not take into account the high proportion of young seral stages and small patch sizes that occur naturally in floodplain landscapes as a result of erosion and deposition.

9.5.1 Biodiversity Guidelines

Seral Stage Distribution

The Biodiversity Guidebook (Ministry of Forests 1995a) recommendation for seral stage distribution for NDT1 and 2 is that 9 to 19% of a Landscape Unit should be greater than 250 years old, depending on the biodiversity emphasis (Table 9). The Skeena Islands Landscape Unit has been assigned a high biodiversity emphasis. The Biodiversity Guidebook further recommends that rare site series such as the high bench Ss-Salmonberry and mid-bench Act-Red-osier dogwood be retained in greater proportion than they occur in the Landscape Unit. Thus retention of old seral stages on the floodplain should exceed the 9 to 19% general guideline.

Table 9: Recommended seral stage distribution for the CWH in natural disturbance types found in the study area (% of forest area within the Landscape Unit).

Seral stage	Early (<40 yrs)			Mature (>80 yrs) + old[1]			Old (>250 yrs)		
Biodiversity emphasis	**Low**	**Int[2]**	**High**	**Low**	**Int[2]**	**High**	**Low**	**Int[2]**	**High**
NDT1	n/a	<30	<23	>18	>36	>54	>13	>13	>19
NDT2	n/a	<36	<27	>17	>34	>51	>9	>9	>13

1. The minimum requirement for the old seral stage is included in the "mature + old" category.
Note: The lower biodiversity emphasis option was established based on the assumption that it would not be applied to more than approximately half the area of any biogeoclimatic subzone within a subregional plan or FD.
2. Intermediate.

Patch Size

The patch size distribution recommended for the Skeena River floodplain is presented in Table 10. The distribution of patch sizes in this Landscape Unit will be influenced by island size on the floodplain. No patch size analysis has been done for this Landscape Unit (Ministry of Forests 1995a).

Table 10: Recommended distribution of patch sizes (harvest units and leave areas) for NDT1 and 2.

	Patch size (ha)		
	<40	**40-80**	**80-250**
% of forest area	30-40	30-40	20-40

Connectivity

Connectivity is defined as the degree to which late successional ecosystems are linked to one another to form an interconnected network. This concept can be applied to how well similar ecosystems are connected (e.g. riparian areas), or to how well different ecosystems are connected (e.g. riparian areas to upland areas) (Ministry of Forests 1995a). Connectivity in this Landscape Unit is complicated by the fragmented nature of the floodplain, with its many islands and backchannels. Large contiguous areas of old forest such as were commonly found in other parts of the CWH biogeoclimatic zone are lacking due to the island nature of the floodplain. In the study area, connectivity can largely be maintained through riparian area management that maintains older stands along the margins of the islands, where features such as game trails tend to be concentrated, and by the linear nature of the river itself.

Stand structure

Vertical and horizontal structure and other stand attributes such as snags, veteran trees and CWD are important in maintaining biodiversity in NDT1 and 2. There are presently no targets for stand structure attributes. Maintenance of stand structure can be done through partial cutting, stand management, preserving veteran trees, and retaining wildlife tree patches (Ministry of Forests 1995a). Structural attributes of floodplain forests may be substantially different from those of upland forests because of the presence of deciduous tree species, high shrub cover, high density of large trees, active disturbance history, and large amounts of CWD (Bunnell et al. 1999).

Species composition

The Biodiversity Guidebook recommends that a significant proportion of the landscape unit has a plant species composition similar to that which developed under natural succession, and that complete conversion from one seral stage to another or to non-native species be avoided. Other recommendations are that rare forest types (less than 2% of the area in landscape unit) be maintained over the rotation, and that the proportion and distribution of deciduous species be maintained as found in unmanaged stands.

On the Skeena River floodplain, where previous harvesting has been extensive, the species composition has probably been modified from that of the unmanaged stands, with an increase in the proportion of deciduous stands. These stands are probably younger and more even-aged than the unmanaged stands. Moreover, because rare forest types cover much greater than 2% of this landscape unit and are rare at a regional and provincial scale, the 2% recommendation is not biologically defensible in this case. Large-scale conversion of the present stands to hybrid poplar stands is one example of a management strategy that would be contrary to the species composition recommendation of the Biodiversity Guidebook.

9.5.2 Riparian Area Guidelines

Under the Riparian Management Area Guidebook, (Ministry of Forests 1995b), a Riparian Management Zone (RMZ) that extends to the edge of the active floodplain or is a maximum of 100 metres wide is required on large rivers such as the Skeena, but there is no requirement for a no-harvest Riparian Reserve Zone (RRZ). In areas managed for hardwood species, the primary objective is to ensure the continued presence of old hardwood trees along the river channel and other key habitats for their wildlife values. Priority areas are within 20 metres of the stream bank, backchannels, side channels and sloughs, and any wildlife trees. In these areas a minimum of 50% of the trees (dominants with large branches and open crowns) are to be retained. Special provisions are made for small islands and subsequent harvests. The guidelines for softwood management on active floodplains are somewhat different than those for hardwood management; they focus on retaining sufficient large trees to reduce the risk of accelerated channel formation and channel erosion. Practices include feathering cutblock edges to reduce windthrow risk, 70% to full retention of trees, retaining non-merchantable vegetation, and following wildlife tree guidelines.

The lack of a no-harvest RRZ and the allowance of harvesting in the RMZ of large rivers are based on the premise that CWD is of lesser importance to large river systems than on smaller streams (Ministry of Forests 1995b, Beedle, 1999). This review, however, has indicated that CWD and logjams are important to river dynamics and provide important fish habitat. There is a concern that lack of CWD or a change in type of CWD may be affecting the stability of the landforms in the lower Skeena system. Recent cottonwood harvesting operations in the area have left a 50-metre no-harvest buffer along the mainstem of the river and a 30-metre no-harvest buffer along all other areas with fish habitat (Acer Resource Consulting 2000). These buffers were retained to protect the integrity of the riverbank and to provide visual screening for wildlife, especially moose.

The present riparian guidelines represent a fairly inflexible approach to riparian management with set riparian zone widths and objectives. Approaches that set goals for certain subsections of the riparian zone have been advocated to allow more flexibility and more targeted protection of sensitive areas. This approach would be based not on the size of the stream but on the function of the riparian area. For example, in a wildlife corridor area the RMZ might need to be wider than in areas where the goal is to buffer the streambank (Burton 1998).

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Appendix 1: Common and Latin names used in the text

Plants

Bunchberry	*Cornus canadensis*
Cottonwood	*Populus trichocarpa*
Devil's club	*Oplopanax horridus*
Enchanter's nightshade	*Circaea alpina*
False-lily-o-the-Valley	*Maianthemum dilatatum*
Hardhack	*Spiraea douglasii* ssp *douglasii*
Huckleberry	*Vaccinium* sp.
Lady fern	*Athyrium felix-femina*
Oakfern	*Gymnocarpium dryopteris*
Ostrich fern	*Mattucia struthiopteris*
Pacific willow	*Salix lucida ssp. lasiandra*
Red alder	*Alnus rubra*
Red elderberry	*Sambucus racemosa* ssp*. pubens*
Redcedar	*Thuja plicata*
Red-osier dogwood	*Cornus stolonifera*
Salmonberry	*Rubus spectabilis*
Sitka spruce	*Picea sitchensis*
Sitka Willow	*Salix sitchensis*
Stink currant	*Ribes bracteosum*
Sweet-scented bedstraw	*Galium triflorum*
Western hemlock	*Tsuga heterophylla*

Animals

Bald eagle	*Haliaeetus leucocephalus*
Black bear	*Ursus americanus*
Black-tailed deer	*Odocoileus hemionus*
Chinook salmon	*Oncorhynchus tshawytscha*
Chum salmon	*Oncorhynchus keta*
Coho salmon	*Oncorhynchus kisutch*
Cutthroat trout	*Salmo clarki*
Dolly Varden	*Salvelinus malma*
Grizzly bear	*Ursus acrtos*
Marbled murrelet	*Brachyramphus marmoratus*
Moose	*Alces alces*
Northern flicker	*Colaptes auratus*
Northern goshawk	*Accipiter gentilis*
Pileated woodpecker	*Dryocopus pileatus*
Pink salmon	*Oncorhynchus gorbuscha*
Steelhead trout	*Oncorhynchus mykiss*
Vole	*Microtus sp.*

Pests and diseases

Northern tent caterpillar	*Malacosoma californicum pluviale*
Poplar and willow borer	*Cryptorhynchus lapathi*
Poplar leaf and shoot blight	*Venturia populina*
Spruce weevil	*Pissodes strobi*