SUSITNA
HYDROELECTRIC PROJECT

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RIPARIAN VEGETATION SUCCESSION REPORT

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NOTICE

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SUSITNA PROJECT OFFICE

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SUMMARY

The Susitna River is a large river in southcentral Alaska where a large hydroelectric project has been proposed. Vegetation along the river is affected by summer floods and ice scour during breakup. The lower limit of vegetation is associated with normal summer water levels except in a few areas where ice jams repeatedly occur. Shrub-sized vegetation is an important resource for moose forage, and is found predominantly in early and late successional stages of vegetation. There is concern about the effect changes in water levels as a result of project operation would have on vegetation and moose browse in particular. These studies were intended to provide an understanding of the existing riparian dynamics and to suggest what might occur with the project in operation.

The earliest stages of vegetation were dominated by horsetail (Equisetum variegatum), balsam poplar (Populus balsamifera), and feltleaf willow (Salix alaxensis) and generally occurred 5 to 15 years after island stabilization. These sites were good sources for browse, but many stems were too short to be available above winter snow. Intermediate stages included sites dominated by alder (Alnus tenuifolia) and immature balsam poplar. Sampled sites had relatively little browse, but sometimes willow in narrow strips of alder might be important for browse production. Alder would dominate the vegetation from 25 to 45 years after island stabilization while balsam poplar would dominate for 55 to 85 years afterward. Mature and decadent balsam poplar communities of later successional stages had the most available browse by twig count because of the well-developed shrub understory and open overstory. It dominated from 100 to 150 years. Similarly paper birch (Betula papyrifera) - white spruce (Picea glauca) types contained considerable browse and dominate after 180 to 200 years.

Lower summer flows with the project would make new land surface available for colonization by plants in summer provided soil moisture and texture were suitable. The lower water levels may delay vegetation colonization because moisture is critical during spring germination. Higher winter levels with ice staging would flood newly established vegetation, preventing colonization by anything except annuals. Areas above the ice front would not be subject to this, but the coarse substrate and low summer water levels may slow colonization. Further development of existing vegetation would probably not be hampered unless the lower water tables had an effect on species composition.

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Most of Tables 3-30 and some of the successional sequence descriptions were modified from McKendrick et al. (1982).

PREFACE

This is the second draft of the Riparian Vegetation Succession Report.

The most important sections for an understanding of present vegetation dynamics and possible effects of the Susitna Hydroelectric Project are the Conceptual Model and Project Effects. The other sections contain supporting information. Readers pressed for time can probably get what they need from the Model chapter, referring to earlier sections as needed for additional details and background. The Site Histories sections contain a lot of detailed information on changes at or near our sites and are included to explain how we arrived at our understanding of vegetation succession along the Susitna River. Readers only interested in a synopsis can probably skip those sections.

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1. INTRODUCTION

The Susitna River (Figure 1) is approximately 320 miles long and drains about 19,600 square miles of land. The river basin is bordered on the north and west by the Alaska Range, on the east by the Talkeetna Mountains and the Copper River lowland, and on the south by Cook Inlet. Its major tributaries include the Chulitna, Talkeetna, and Yentna rivers (Bredthauer and Drage 1982). The proposed Susitna Hydroelectric project will include dams initially at Watana and later at Devil Canyon.

The floodplain along the Susitna River below the dam sites contains dynamic vegetation relationships. Vegetation is important for island stabilization and wildlife habitat, especially moose browse production. The existing river dynamics are responsible for maintaining vegetation in early successional stages or eliminating older sites and providing new areas for colonization by plant species.

Peak discharges frequently occur in May and June under natural conditions, but average water levels are usually higher in July and August during the summer rains. High spring water levels frequently occur when seeds of early successional species, such as balsam poplar (*Populus balsamifera*) and feltleaf willow (*Salix alaxensis*) are being dispersed. The lowest water levels occur in September, October, and November before ice-related staging raises water levels to near summer conditions. This cycling of water levels allows seeds to be deposited in the spring, the only time when these seeds are viable, and to grow if there are no significant floods later in the summer. Vegetation may not colonize each year if conditions are not suitable for seed dispersal, germination, and plant establishment. Other means of dispersal could also account for some establishment. The key factor in plant establishment appears to be high water during spring glaciers to the confluence with the Oshetna river; the middle river runs from there to the Chulitna river confluence and includes the impoundment zones; and the lower river extends from the Chulitna confluence to the river's mouth at Cook Inlet. Because the Susitna River Hydroelectric Project would have no effect on the upper river, most of the following discussions concentrate on the middle and lower river.

dispersal followed by a period of lower water sufficient to allow seedling establishment. These flows provide moisture for germination in June and only limited inundation for the young plants in July and August. Lack of flooding in winter and insulating snow cover are also favorable for growth.

The average water levels with the project in place will be much lower in summer than they are now (10,000 cfs Gold Creek with project versus 23,000 cfs average under natural conditions) and higher under winter ice cover with staging water levels corresponding to (30,000 cfs versus 20,000 cfs open water) (Harza-Ebasco 1984c, 1985). Flooding will inundate established vegetation in some places, causing it to be ice-covered for up to 4 months each winter. Flooding and ice jamming effects which give the system a pulse to set back vegetation succession under natural conditions will be dampened by river regulation. Ice jamming effects will be almost nonexistent in the middle river because ice will melt out in place rather than through a forceful breakup.

Concern exists about the effect of changes in river flow and ice regimes on the vegetation and moose browse. Will the new areas available for colonization be vegetated? Will vegetation advance uninterrupted and reduce the amount of moose browse? Will vegetation succession be set back occasionally to increase moose browse? To be able to predict what might happen with the project, one must understand the existing system and what makes it work. Understanding plant ecology, including the effects of river hydrology, is necessary for interpretation of the existing system. Only then can reasonable projections be made of the project impact.

For simplicity of discussion, the Susitna River will be divided into three zones. The upper river is considered to extend from the Susitna glaciers to the confluence with the Oshetna river; the middle river runs from there to the Chulitna river confluence and includes the impoundment zones; and the lower river extends from the Chulitna confluence to the river's mouth at Cook Inlet. Because the Susitna River Hydroelectric Project would have no effect on the upper river, most of the following discussions concentrate on the middle and lower river.

2. GEOMORPHOLOGY OF THE SUSITNA RIVER

The Susitna River originates from several glaciers that drain the east-central Alaska Range, principally the Susitna, East Fork, West Fork, and Maclaren glaciers. The river runs in a southerly direction for about 86 miles, then turns abruptly westward near the Oshetna River confluence. It then runs generally westward for about 135 miles before turning broadly to a southerly direction again. The river then flows essentially southward for the remaining 99 miles to Cook Inlet.

2.1 Middle River

2.1.1 Geomorphic History and Processes

During the Pleistocene ice age, the Susitna River valley was filled with glacial ice that extended all the way into Cook Inlet. When the glaciers retreated at the end of the Pleistocene about 10,000 years ago, the Susitna River began to cut down through the glacially-eroded bedrock surface in the Susitna basin, eventually cutting canyons several hundred feet deep in the miiddle river reach. Today the middle river flows through the canyon floor on a riverbed characterized by single-channel and split-channel patterns (Table 1).

As the river cut, or degraded, its way into the canyons, the active floodplain elevation slowly dropped below old riverbed level. Some older levels are evidenced today by the presence of extensive sedimentary terraces perched above both sides of the river. These old terraces are sometimes high above the river, are generally covered by old forests, and they are not affected by river processes such as flooding. Some terraces are, however, breached by sloughs, indicating historic overtopping events which flooded these terraces.

The middle river slowly underwent degradation of its channel for thousands of years, and studies show that it appears to have been in progress from 1949 to the present (AEIDC 1985). Although new gravel bars form, migrate, and change shape through sediment redistribution, many gravel bars apparently emerge and become more and more exposed at the surface as the river degrades. Eventually, some bars rise high enough above the river level that they are seldom affected by flooding or ice processes, and they become stabilized islands with mature vegetation. Many emergent gravel bars have become attached to the riverbanks and are now forested terraces at various elevations above the modern river floodplain.

Most of the river's flow is carried by the mainstem channel, which is the deepest channel or "thalweg". Mainstem waters are turbid in summer, due to high concentrations of suspended glacial silts. In winter, mainstem waters are generally clear because glacial melt ceases. Side channels and sloughs are overflow channels. Water flows into them from the mainstem only during high flow periods or during ice staging, when flows are high enough to overtop intervening gravel berms. At the mouths of sloughs, backwater effects from the mainstem always contribute to slough water flow. In sloughs and some side channels, water also flows from mainstem-influenced ground water upwelling, other springs and seeps, and side slope brooks and rivulets (Bredthauer and Drage 1984a). All of these waters are clear.

As the river degrades and gravel bars emerge, side channels that once ran behind some gravel bars also emerge and become "perched". In this way, many side channels evolve into side sloughs, and side sloughs evolve into upland sloughs (AEIDC 1985). Some channels eventually become perched so high that they no longer carry river water under any circumstances, and they become vegetated. Old channels of this type are found on many of the stable, forested islands and terraces.

2.1.2 Effects of River Ice

For about 7 months of each year, ice dominates the river system, advancing during freezeup, dynamically changing during mid-winter, and dramatically flushing out of the system during breakup. Some of the processes of ice formation and decay have a permanent effect on river morphology, vegetation, and fish and wildlife habitats.

Although river flows and geomorphic regime (the balance of aggradation and degradation over time) are major factors controlling channel evaluation, ice processes also appear to influence river morphology in the middle river zone. For example, formation and alteration of some sloughs may be related to breakup ice jams, and riparian vegetation may be bent and scraped by ice scour.

Some of the sloughs may have been formed when breakup ice jams caused the river to stage upstream of the jams. This process was observed to occur in 1976 at Slough 11 near Gold Creek (R&M Consultants, Inc. 1984a). At this site an upland slough was changed to a side slough. Floods overtopped the river banks and flowed through depressions in a terrace. Ice blocks carried in by the floods eroded away the terrace materials, substantially lowered the elevations of the entrance berm, and th4n deepened and enlarged a slough channel.

Vegetation along riverbanks and on islands is affected by ice conditions. The vegetation line along the riverbanks in the middle river is sometimes determined by the height to which eroding ice blocks reach during breakup in locations where jams frequently occur. Also, vegetation on the upstream ends of vegetated islands is sometimes affected by breakup ice jams. Islands frequently subjected to ice jams have several ice-scarred mature trees not only adjacent to cut banks but also further in the interior of the stand. Some stands of young trees that occupy the upper ends of islands may be second generation growth after a major ice jam event broke tree trunks at ground level in an earlier stand (R&M Consultants, Inc. 1984a).

2.1.3 Sediments

Bed materials of the Susitna River are composed principally of gravel and cobbles, with a minor amount of sand. The median size of sediments in the mainstem is somewhat larger than those in side channels, and sediment sizes along riverbanks are somewhat larger than those in channels. Bed material size distribution in the middle river is shown in Table 2 (Harza-Ebasco Susitna Joint Venture 1984a). Most of the middle river mainstem bed is composed of medium to large gravel, cobbles, and boulders until reaching the vicinity of the Susitna-Chulitna rivers confluence, where the riverbed sediments abruptly become smaller and more transportable as a result of inputs from the Chulitna.

Compared to the lower river, which is largely influenced by the Chulitna River, the middle Susitna River carries relatively little transportable bedload. Principal contributions of sediment to the middle river are from glacial sediments from upriver, talus slopes, mass wasting, erosion of river banks, and sediment contributed from tributary streams (R & M Consultants, Inc. 1982).

Much silt, coming from the glaciers and from runoff upriver, is deposited in the middle river, especially during high flow events. However, some silt is deposited in backwater and low-velocity zones of the river system during breakup. These sediments are then redistributed downriver during summer floods (R & M Consultants, Inc. 1984a). Silts are often deposited during breakup at the upper ends of ice jams where staging occurs and water velocity slows, allowing finer sediments to deposit on gravel bars, islands, and low terraces, and some silt is deposited directly from melting ice blocks.

Some slough channels are overlain with fine sands and silts during low-flow events. These fine sediments are then removed during high-flow events, such as summer floods.

2.2 Lower River

2.2.1 Geomorphic Processes

The lower river flows over a thick deposit of sediments laid down over thousands of years by the Susitna and Chulitna rivers and their tributaries. Near the Susitna-Chulitna confluence, the Susitna River changes abruptly to a braided and multiple channel pattern for the remainder of its length. In the Delta Islands area from about RM 61 to 42, the river has a combined pattern, with a braided pattern on the west side of the islands, and a multi-channel pattern on the east side. A summary of river patterns in the lower river is presented in Table 1 (R & M Consultants, Inc. 1982).

Braiding appears to be related to a number of factors, including the following (R & M Consultants, Inc. 1982):

1. Abundant sediment load and high transport rates;
2. Large and sudden discharge variations;
3. High gradients;
4. Low channel stability;
5. Erodible banks.

All of these factors are present in the Chulitna River. The lower river seems to be dominated by the braiding patterns developed in the Chulitna River. The regime of the river below the Susitna-Chulitna confluence suggests that the middle Susitna River is morphologically a tributary of the Chulitna River rather than the other way around as it is usually considered.

Large braided rivers like the Susitna have wide channels, rapid shifting of bed materials, and continuous shifting of the position of the river course. The amount of channel shifting varies with flow fluctuations (Leopold et al. 1964).

The Chulitna River has an abundant sediment supply from a number of large glaciers in the nearby Alaska Range. Consequently, the lower river is much nearer to that sediment source than to the distant glacial sources in the upper Susitna River.

Channel pattern in the lower river are quite dynamic, and river morphology here is related primarily to summer high-flow events. When summer disharges overtop gravel berms between the mainstem and side channels, bed material is set in motion, often resulting in changes in channel network configuration and shape (R & M Consultants, Inc. 1982).

Bars in gravel-bed braided rivers are usually predominatly longitudinal bars, having their long axis aligned downstream. Active sediment transport over river bars usually results in a decline in deposited sediment size moving down-bar, reflecting a down-bar decline in stream power (Richards 1982). Bar morphology often changes systematically downstream, however. Boothroyd and Ashley (1975) found that, on the Yana outwash fan near the Malispina Glacier, bars changed in a downstream direction from coarse-gravel longitudinal bars with low bed relief to finer gravel longitudinal bars with somewhat higher bed relief, and then to a combination of sandy longitudinal and lingoid bars.

2.2.2 Effects of River Ice

The lower river has a broad, active floodplain exceeding a mile in width. River staging due to freeze-up can spread over a wide area and, consequently, does not rise very high. No significant overbank flooding takes place.

Several side channels are commonly flooded, but few side sloughs are overtopped, and when they do it is with little flow and carrying little or no ice. The ice cover below Talkeetna is usually confined to the thalweg channel, which usually occupies less than 20 percent of the floodplain width (R&M Consultants, Inc. 1984a).

Breakup is generally quite gentle, with no dramatic ice drive. At most a few small ice jams occur at the lower ends of open leads as the ice cover melts away in the early stages of breakup. The lower river is usually nearly melted out before the breakup drive from the middle river occurs, so no massive ice jams occur. When the middle river drive occurs, its ice floats through the lower river to Cook Inlet.

2.2.3 Sediments

The Chul a and Talkeetna rivers contribute about 80 percent of the total sediment load to the lower Susitna River. Bed materials in the lower river are finer than those in the middle river.

Sediment sizes are extremely varied in proglacial braided rivers, varying from silt-clay low-energy deposits, such as those found in abandoned channels and overbank deposits, to high-energy gravels on active river bars and in migrating channels.

Sediment sizes generally become smaller downstream, and the sorting of sediment sizes improves. At the Susitna-Chulitna confluence, coarse gravel predominates. Downstream the materials become finer. Near Talkeetna, the bed materials are composed of 70 percent cobbles and 30 percent gravel. At Sunshine, where the Parks Highway bridge crosses the lower river, the bed materials are composed of 29 percent cobbles, 66 percent gravel, and 5 percent sand (Harza-Ebasco Susitna Joint Venture 1984). Nearer the river mouth, sand dominates the composition of many river bars.

Once a river bar emerges above the surface of the water it may become stabilized by vegetation. This helps prevent the island thus formed from being easily eroded and also tends to trap fine sediments during flooding or eolian deposition. In this manner many bars become coated with a veneer of silt (Leopold et al. 1964).

A large proportion of total annual bedload transport takes place during the short periods of summer flooding. During summer high-flow events, large amounts of bedload sediments are redistributed throughout the lower river. Localized occur almost continuously. However, on a long-term basis, the lower river appears to be in equilibrium (Harza-Ebasco 1984).

3. VEGETATION BACKGROUND

3.1 Vegetation Succession

Numerous studies have reported on vegetation development along rivers, even in the boreal and arctic climatic zones. Succession sequences on river alluvium along the Colville River near Umiat, Alaska, and other locations in northern Alaska were studied by Bliss and Cantlon (1957). Several species of Artemisia, legumes, and other forbs became established on sands and silts deposited on top of gravel. Most feltleaf willow (Salix alaxensis) came from clumps along banks that had caved in, and few seedlings were observed. These earliest successional areas graded into those dominated by young and then decadent feltleaf willow, which may be 10 cm in diameter and be 46 years old. These are much larger willows than what we normally find on the Susitna River (McKendrick et al. 1982). More feltleaf willow was found on gravelly alluvium than on sandy or silty materials (Bliss and Cantlon 1957) in contrast with Susitna. Communities dominated by alder (Alnus tenuifolia) shrub-dwarf heath meadow occurred on terraces, sharply separated from the early stages.

Viereck (1970) described vegetation and soils from four different successional stages along the Chena River near Fairbanks, Alaska. The earliest stage sampled was a 15-year old feltleaf willow stand, dominated by herbs and shrubs with light weight seeds. Balsam poplar (Populus balsamifera) was generally established at the same time, but its growth was slower. After balsam poplar grew taller than the willow, rose (Rosa acicularis) and highbush cranberry (Viburnum edule) became important in the understory, similar to what occurs along the Susitna. Willow was established on soils with particles greater than 2 mm in size constituting 5% of the material and 92-98% of the remaining material being sand. This contrasted with the finer textures where willow grows along the Susitna River (McKendrick et al. 1982).

Along the Chena River balsam poplar dominated the canopy in stands that were approximately 50 years old, then white spruce (Picea glauca) became dominant 120 years after stabilization (Viereck 1970). Older balsam poplar sites on the Susitna were over 100 years old, and white spruce was just becoming important in the understory, although the time frame for white spruce establishment was very variable (McKendrick et al. 1982). Mixed stands of white and black spruce (Picea mariana) dominated 220 year old stands along the Chena (Viereck 1970) while paper birch (Betula papyrifera)-white spruce dominated 200-year old stands along the Susitna (McKendrick et al. 1982). Mature sites along the Chena River were underlain by permafrost (Viereck 1970), which was not present on the Susitna.

Dyrness et al. (1984) reported on succession along the Tanana River near Fairbanks in interior Alaska, with results somewhat similar to Viereck's (1970) results for the Chena River. Silt bars were colonized by several species of willow, alder, and balsam poplar, with the first two species dominating for 15 to 20 years. Poplar then grew taller than them and dominated for the next 60 to 80 years. White spruce sometimes invaded rapidly or became established over a period of years, but eventually it grew taller than the poplar. The establishment of white spruce depended on periodicity of the seed crop, distance to seed source, floods, silt deposition, and other factors affecting seed dispersal, germination, and establishment. Black spruce eventually dominated. This sequence closely paralleled results along the Susitna except the Susitna has a birch-spruce rather than a spruce stage.

Nanson and Beach (1977) reported a similar successional sequence along meanders on the Beatton River in British Columbia. They reported that white spruce seedlings occurred, but did not survive, on sites less than 60 years old. This would agree with our data where spruce are older and taller at an intermediate stage of succession rather than at a later stage. Spruce in British Columbia required mineral soil and some shade. Three generations of white spruce might occur before black spruce dominated. Nanson and Beach (1977) also observed that the poplar to spruce transition occurred relatively rapidly with no mixed stage. This was similar to our observations where poplar-spruce stands were relatively rare compared to mature poplar or birch-spruce alone.

Craighead et al. (1984) have briefly studied vegetation succession along the Stikine River in southeast Alaska to assess the impact of a hydroelectric project on moose browse in the downstream reaches. Newly exposed riverbanks were colonized by several species of horsetail (*Equisetum variegatum*, *E. arvense*, *E. fluviatile*) and willow (*Salix alaxensis*, *S. interior*). Other willow species entered later. Feltleaf willow became less important as alder (*Alnus rubra*) and black cottonwood (*Populus balsamifera* ssp. *trichocarpa*) became more important.

Gill (1972) used vegetation to categorize certain alluvial environments in the Mackenzie River delta since different vegetation reflected fluvial and aeolian sedimentation processes. Fine sands were more important at upstream ends of point bars while silts were more important at the downstream ends. This was attributed, at least in part, to helicoidal flows causing shifting rather than meandering channels. Balsam poplar occurred primarily on these point bars which had warmer soils and better root aeration than other areas that were underlain by permafrost or high water tables. Balsam poplar, willows, and forbs were important early colonizers. Barclay willow (Salix barclayi) was an important shrub less than 1.6 m tall, but feltleaf willow was important in the layer up to 6 m tall. Feltleaf willow was by far the most common willow on the Susitna River, but it was generally less than 2 m tall (McKendrick et al. 1982).

Sigafoos (1964) extensively studied flood history along portions of the Potomac River near Washington, D. C., based on evidence from trees. The establishment and maturation of trees resulted from interrelated sequence in the timing of seed dissemination and germination, suitable environmental conditions, and flow regime of the river. Flood history could be determined from buried tree rings since new wood formed on a buried trunk is more like root wood than stem wood. All trees could withstand 1 m of sedimentation. Alestalo (1971) also reported on the use of differences in wood to determine when various stresses occurred to trees. Observations from these two authors had been used in our earlier descriptive studies (McKendrick et al. 1982).

3.2 Seed Dispersal and Germination

Bo'' the type of seed (Howe and Smallwood 1982) and time of dispersal (Densmore and Zasada 1983, Zasada et al. 1983) are important adaptations of various species. Early colonizers are balsam poplar and willows which have light seeds dispersed early in the growing season (Densmore and Zasada 1983). These early seeds have no dormancy and may produce cotyledons within 2 days of landing on a suitable site (Densmore and Zasada 1983). According to Buch (1960 cited in Densmore and Zasada 1983), willow seeds have chlorophyll, transparent seed coats, and little or no endosperm. Feltleaf willow germinated later then other willows, aspen, and balsam poplar that were tested, and it required 3 - 4 weeks for germination of 80% of the seeds (Zasada et al. 1983). Ware and Penfound (1949) and others have reported short viabilities for cottonwoods and some willows. Schreiner (1974) reported many poplar seeds may produce elongated hypocotyls and cotyledons, but not have enough vitality to produce a normal plant. Germination required a saturated seedbed, and seedling survival depended on favorable conditions for at least one month (Schreiner 1974).

Paper birch and white spruce seeds are relatively heavy, dispersed in the fall (Zasada et al. 1983), and are dormant at the time of dispersal. Forty percent of the fall-dispersed seeds germinated before summer dispersal began (Zasada et al. 1983). This may have enabled them to take advantage of snow melt. Winged white spruce seeds may reach heights above the cone where they were released and may travel circuitous routes (Zasada and Lovig 1983). White spruce seeds may also be transported by water. Safford (1974) has observed that spruce seeds may fall all year and that partial shade is important for the seedlings. Birch seed fell all winter, but only 10-15% travelled over 51 m (Clautice 1974). White spruce was considered relatively heavy seed and it fell within 64 m of parent. Mineral soils were generally required for seedling establishment (Zasada and Lovig 1983, Zasada et al. 1983). Fowells (1965, cited in Clautice 1974) reported that some species became established on mineral soil exposed by windthrows, which was similar to our observations. The only young birch trees we observed in old poplar or poplar-spruce stands were growing on such sites. Brinkman (1974) reported that birch seedlings require light shade for 2 - 3 months.

Spruce germination started 1 week later than that for birch, reached its peak 3 weeks later, and was more evenly distributed over the growing season (Clautice 1974). This left spruce seeds more vulnerable to predation but enabled some young to take advantage of better survival conditions. Rising water tables in late summer resulted in mortality from damping off, flooding, and overgrowth by other vegetation. June and August germinants had the best survival on the north-facing slopes while July and August germinants did best on the south-facing slopes.

3.3 Flooding Effects

Flooding is known to affect different species to different degrees. Armstrong (1968, cited in Armstrong 1982) reported that some species have adapted to flooding by having lenticels in the stem that provide for oxygen exchange. If these lenticels are low and become flooded, the roots may die. Flood-adapted species produce adventitious roots in response to a rising water table. Lees (1964) observed that roots of white spruce seedlings degenerated if waterlogged for too long. However, tolerance to flooding increased if any foliage was above water. He noted that even bog species required aeration by lateral movement of water or water fluctuation. In other words, moving water moving from a flood would not be as harmful as impounded water, even if vegetation were subjected to these conditions for the same period of time (Kozlowski 1984).

Winter flooding and freezing might be harsher than summer flooding because the ice prevents air exchange between the below- and above-ground atmospheres (Smith 1981). This is fatal to many plant species and to young plants of adapted species. Even though plants are dormant at this time, the roots still respire.

4. METHODS

Two approaches were used in sampling the vegetation for this successional study. The initial study performed in 1981 was intended to describe the various successional stages along the river and to evaluate their usefulness for moose. Determination of a successional sequence and time frame was secondary. Unanswered questions regarding successional sequence and time frame for the various stages were addressed in our revisit of the sites in 1984. Hence, sampling of ages was deliberately oriented toward older individuals or coring fallen logs. Densities were only recounted on browse species, and cover was only estimated on early sites or sites where changes were apparent. The only complete data set was collected in 1981, and the 1984 data were used to explain more details of the succession and changes that have occurred.

4.1 1981 Methods

The original quantitative descriptions of downstream floodplain plant communities were based on sampling 29 stands between the Deshka River and Chase (Figures 2-10). Reconnaissance of the area in August 1980 and again in early summer 1981 was used to determine the types of floodplain vegetation present. In June 1981 a series of points systematically plotted on aerial photographs was classified by helicopter survey and used to determine the relative availability of each of the types. Sample sites were then selected in each successional stage in each of three reaches of the river: Deshka River to Sheep Creek, Sheep Creek to Birch Creek Slough, and Birch Creek Slough to Chase.

Stands of middle and late successional stages were required to be of sufficient size and uniformity to allow placement of four randomly oriented, non-overlapping 30-m transects. Initial data analysis indicated that more transects were needed for adequate sampling. In August, two more transects were used in most of these stands (except two alder stands which were sufficiently uniform) and four more transects were used in one of the highly variable birch-spruce sites (site 4). Early successional stands were sampled with four transects in a homogeneous area where possible. However, many of these areas were too small and as few as two transects were used in some places. Sometimes one transect would be taken in one patch and another in a nearby, but not contiguous, area.

The 30-m transects with nested rectangular plots had been selected as the most reasonable way to sample everything from early successional sites with sparse vegetation cover and small plants up to mature sites with dense, multilayered vegetation. It may not have been the best way of sampling the early stages and the transect should have been longer in some of the mature stages, but it worked well for a general description of the stages, which was the original objective. A more detailed study should probably use more but smaller transects in the early sites and either more or larger transects in the later sites. The large scale of pattern presented by trees made it difficult to sample across all the variability with only a 30-m transect. Smaller sampling units would be better in the early stages to avoid confounding of microsites. The problems with the transect size or numbers of transects were not apparent until the sites were resampled in 1984 and the data from the two years compared. Installation of "permanent" markers may eliminate much of the variability of transect placement in future years.

Vegetation cover by species was recorded on two to eight transects at points spaced 50 cm along a tape measure. Observation of points in the overstory was aided by use of a set of cross-hairs in a sighting scope.

Woody species density was determined by counting the number of individuals by height class rooted within a designated plot alongside the length of the transect. Shrubs < 0.4m, 0.4 to 2 m, and > 2 m but < 4 cm dbh (diameter-breast-height) were counted in a 1-m plot alongside the transect. Tall shrubs (>2 m in height and > 4 cm dbh) were counted in a 2-m wide plot while trees (> 4 m tall) were counted in a 5-m wide plot. An individual was defined as any stem emerging at the surface of the litter, whether it had the same parent roots as its neighbor or not.

These size classes were designed to separate browsable stems from unbrowsable stems. Woody stems less than 0.4 m tall were considered unavailable because of snow. Snow depths have never been measured on any of our sites in the middle of the river where the environment may be different from that on the snow courses which were located in forest openings at Alexander Lake (1964-1982), Willow airstrip (1964-1982), and Talkeetna (1967-1982). Mean snow depths over these courses range from 0.7 m to 1.0 m on the February 1, March 1, and April 1 readings. Given these facts and that snow depth increases through winter, 0.4-m depths may not accurately represent late winter conditions in mid river.

Age, height, and dbh of important tall shrubs and trees were measured on two randomly selected individuals along each transect in 1981. Important low shrubs were also measured for height, length, and width. Heights of tall individuals were measured with a range finder. The age of each measured tree or shrub was determined by counting growth rings taken from cross sectional cuttings or cores. Ages of four individuals per transect were determined in 1984 with emphasis on older individuals. Measurements were also taken on low shrubs in 1984 so that increase in height of vegetation in the stands could be estimated.

Crown dominance was a measure of which species were capturing the canopy sunlight. It had the following values: (1) open grown (not encountered), (2) dominant - received sunlight from above and the sides, (3) codominant - received sunlight from above but not the sides, (4) intermediate - barely reaching main canopy, (5) overtopped - below general level of canopy, (6) subordinate - under overtopped, and (7) ground - lowest level. Crown dominance is very different from absolute height and is similar to relative height. Individuals in early succession sites may be dominant even if they are only 0.5 m in height if nothing else is growing above them. Five-meter tall stems may be overtopped or subordinate in later vegetation stages, depending on the other vegetation. This was not remeasured in 1984 because the only places that it changed were where species had been virtually eliminated.

4.2 1984 Methods

Methods in 1984 were designed to measure change and enhance understanding of the successional sequence and time frame. All sites were revisited to the extent possible. Two were on sand bars in areas with many unvegetated and slightly vegetated bars that looked alike and were constantly shifting so exact relocation was not possible. One alder site had been almost entirely eroded away, and it was impossible to resample it.

Permanent transects and photo points were established to monitor future vegetation changes. Ends of the transects were marked with electric conduit and surveyor's flagging. Photographs were usually taken from both ends of the transect, usually a detailed photograph of the vegetation and one looking into the distance with a landmark. These worked well in the early stages. However, the vegetation was too dense in later stages to get a meaningful horizontal photograph through the vegetation.

One balsam poplar - white spruce site was partially sampled in 1984 whereas none were sampled in 1981. Time limitations prevented a complete sampling of this according to the 1981 methodology, but the understory composition was very similar to that of mature balsam poplar sites. Ages were determined and the site was explored to better understand the transition from balsam poplar to birch-spruce.

On several early sites woody individuals were excavated to determine the age of the stem (Figures 11, 12). Woody species, such as balsam poplar and willow, may survive frequent sedimentation which buries part of the stem. Sometimes an individual was sampled at ground level, and the annual growth rings counted to find 9 years. When the plant was dug up, there might be another 9 years of growth buried. Not all stems have experienced that much sedimentation, but most have had several years of growth buried. Several stems per site were excavated where cime permitted to analyze the sedimentation history as illustrated by bent and buried plants. Cores were also obtained in site 12, an ice-affected site near Whiskers Creek, through bent shrubs and through scars on trees to study the ice-effects history of the site.

Accessible sites were visited during early to mid-May 1984 during melt-out. Lack of precipitation made break up mild, and low water levels made access difficult in places. Browsed and unbrowsed twigs were counted on browsable shrubs to estimate the relative number of available twigs and utilization in different successional stages, where utilization was defined as percentage of twigs browsed. This was not intended to be a browse inventory, but rather to obtain general comparisons.

5. VEGETATION DESCRIPTIONS AND SITE HISTORIES

5.1 Early Successional Stages

5.1.1 General Descriptions

Early successional communities common to the lower Susitna river floodplain and portions above Talkeetna are dominated by horsetail, balsam poplar, willow, and combinations of these, or dryas. These types account for 5-10% of the vegetated land on the floodplains as determined from aerial transects observed from helicopter in June 1981. These communities have relatively little total vegetation cover and greater than 50% bare ground (Table 3). Plant species in these types characteristically have rhizomes, or horizontal underground stems, which may extend for many meters and are effective in binding loose sand and silt. Sprouts generally arise from these rhizomes, thus increasing the vegetation cover in the area. Even sites that are dominated by one of the woody species usually have a significant amount of horsetail present except on very sandy sites.

When sampled in 1981, all the early sites combined averaged 25% cover by horsetail (Table 3). Sandier sites averaged much less than this. Balsam poplar averaged 8% and feltleaf willow averaged 4% cover on these sites. Other characteristics are summarized in Tables 4 and 5. The site histories section will detail the changes between 1981 and 1984.

Although early successional sites had high densities of browse species, many stems in the sampled areas were too short to be browsed. Only 4% of the balsam poplar twigs were browsed while 76% of feltleaf willow twigs were browsed (Table 6). Stems had to be at least 40 cm tall to be counted, but if snow were deeper than that, unavailable twigs might have been counted as available. Hence, they could not be browsed. Many poplars might have fallen into this category. Most feltleaf willow stems were taller than the poplar. The 76% utilization of willow indicated it was a valuable forage resource.

5.1.1.1 Horsetail

Horsetail stands generally had more vegetation cover than other early successional sites with 46% total cover (Table 7). Horsetail provided 41% cover while balsam poplar and feltleaf willow accounted for 2% and 3%, respectively. The dominant horsetail species on the early sites was the perennial Equisetum variegatum. Some other species were probably also present, but certain identification was questionable because of the need for both sterile and fertile stems. The Equisetum genus can sometimes be a very difficult one for identification. Sites that were dominated by horsetail in 1981 included 8, 15, 13, 1, 9, and 14. Sites 8 and 15 were almost exclusively horsetail while site 1 had considerable balsam poplar. Sites 9, 13, and 14 contained an important feltleaf willow component.

Woody stems in the horsetail sites, as in most early successional sites, were relatively short, on the average approximately 50 to 60 cm (Table 8). This was tall enough to be counted as browse using the assumed 40-cm snow depth, but if 70 to 100 cm was a more realistic snow depth, then there was little, if any browse in these stands that would be available in late winter. The most important size class was < .04 m (Table 9). Balsam poplar had a mean age of 5 years above ground, while feltleaf willow averaged 3 years (Table 8).

5.1.1.2 Juvenile Balsam Poplar

Juvenile balsam poplar stands were characterized by 71% bare ground and 14% poplar cover (Table 10). Horsetail provided approximately 5% cover in these sites. Feltleaf willow still averaged about 50 cm tall and 5 years above-ground age, but poplar only averaged 32 cm height in these stands, even though above-ground age was 7 years (Table 11). Hence, growth on these sites was slower than on sites where horsetail was a dominant factor. The juvenile balsam poplar sites were usually very dry with a sandy soil and poor site conditions. Sites with horsetail generally had a finer textured soil and more mesic conditions. Again, the size class with the most individuals was < 0.4 m (Table 12). Sites 5, 20, 21, and 25 typified this type of site.

5.1.1.3 Willow

Sites dominated by willow had approximately the same amount of vegetation cover as horsetail sites, 48%, but only contained 35% bare ground because of additional litter (Table 13). Horsetail provided 25% cover. Feltleaf willow averaged 79 cm height and 6 years of age while poplar averaged 49 cm and 7 years (Table 14). These sites provided better growing conditions than the juvenile balsam poplar sites. Most willow were browsabl-e while most poplar were still too short (Table 15). This kind of site was typified by sites 6, 16, and 22.

5.1.1.4 Others

Dryas sites, as typified by site 18, were characterized by 4% living dryas cover, 7% dead dryas (centers of mats were frequently dead), 50% bare ground (no vegetation, cobbles, or litter), and 27% cover by cobbles and coarse gravel. Balsam poplar contributed 6%.

These early successional stages appeared to last up to 10 years from the last major disturbance. Aging of these stands was difficult because a flood might deposit sediment around, but not destroy, established vegetation in some areas (Figures 11, 12). The vegetation would be buried then resurface. Balsam poplar approximately 50 to 60 cm in height might have 5 to 10 years of growth since the last major sedimentation and another 5 to 10 years of growth under the sediment. Ten years was a lot of buried growth, but it was not unusual to find 3 years of growth buried.

Horsetail-willow and horsetail-balsam poplar plant communities provided a substantial forage resource for moose. Close proximity with cover (mid- and late-successional stands) allowed most such areas to receive use by all age classes of moose during all seasons. However, stands which were located far from protective cover might only have been acceptable to older animals. Horsetail and dryas communities were of little or no value to moose at any time of the year, because the browse was either insufficient or too low-growing.

Browse availability was based on an assumed 40-cm snow depth. In reality, snow depths fluctuate through winter, not reaching maximums until late winter. In mid-to-late winter, snow depths along snow courses in small openings in mature forests near Talkeetna, Willow, and Alexander Lake have been closer to 70 to 100 cm over the past 20 years. However, none of these snow courses were on the floodplain that the authors have been considering. Wind action on the river may produce different results or early successional sites may have more or less snow. If those snow course measurements were reasonable for the study areas, then early successional sites may be less important in late winter than previously thought, since many areas would provide no usable browse at that time.

5.1.2 Site Histories

5.1.2.1 Site 8

Sites 5 through 9 were early successional sites located near each other above Susitna Landing near RM 67, on the east side of the river. Site 8 was a horsetail site between the slough and an unsampled willow-horsetail site. In 1981, it contained 48 % bare ground, 14% litter, 1% balsam poplar, 42% horsetail. By 1984, however, the horsetail had expanded and less than 25% bre ground was present (Figure 13). The woody species had been reduced to numerous current-year seedlings, shaded under the horsetail. The slough adjacent to the site removed several feet of shoreline and became deeper.

A moss layer, similar in appearance to Rhacomitrium spp. (but it has not been identified), has developed, keeping the surface soil in place. This moss layer was noticed in several sites and was associated with finer soils (such as silts and fine sands), and with good soil moisture, but without recent severe flooding. This might reduce soil erosion by wind and water and have an unidentified effect on seedling survival.

The area occupied by sites 5 through 9 had been deposited since 1951, and appears to have been considerably affected by recent and rapid changes in the adjacent river channels as indicated by comparisons of aerial photographs for 1951, 1980, and 1983. The dryas site has been flooded and silt deposited on some dryas. Some of the shallow sloughs through the island seem to flooded frequently enough to prevent seedling establishment. The slough on the southwest side, separating site 9 from the others, has widened and deepened considerably in the last 3 years. If river changes persist at the current rate, the horsetail site 8 will probably be completely cut away in 4 to 8 more years.

5.1.2.2 Site 13

Site 13 was a horsetail site at RM 100 above the confluence with the Chulitna River. It contained recent sediment deposition in mounds where ice blocks had melted away. The deposition was apparent in the hummocky topography of some areas. Comparisons of photographs between 1981 and 1984 indicated an increase in horsetail cover and a lesser increase in willow (Figure 14). However, the willows have definitely grown larger.

The amount of bare ground has decreased from 60% to 42% while the amount of horsetail cover has remained approximately constant at 30%. Woody species accounted for < 2% cover in 1981 while feltleaf willow now accounts for 14%. Balsam poplar and alder provided only 1% cover each while other willow species provided 5% cover.

Balsam poplar densities in the < 0.4-m size class increased 2.2 times from 1981 to 1984 although much of that occurred along one transect. (The increase was 1.5 times without that transect). Feltleaf willow in this class was not detected in 1981, but much was present in 1984. There was 2.7 times as much feltleaf willow in 1984 as in 1981 over all size classes. Tall blueberry willow (Salix novae-angliae) and littletree willow (Salix arbusculoides) also increased between the two years. Balsam poplar averaged 73 cm tall and 4 years old while feltleaf willow averaged 127 cm tall and 4 years old. Feltleaf willow increased in size and abundance while poplar remained about the same. The site had been impacted by ice in 1981, so several years of growth might have been covered with sediment. Hence, ages might not be accurate.

The west side of the island had been completely eroded between 1951 and 1980, but new material had been deposited to its west. Mature vegetation along the west banks of the river had also been cut away. Some areas below site 13 were only sand bars in both 1951 and 1980 while other islands downstream from it have become visibly better vegetated as indicated by the aerial photographs. This site was vegetated in 1951 although not heavily. Lower portions of it were flooded in the August 27, 1983, photographs (average daily flow 31,000 cfs Gold Creek) but not in the September 16, 1983 photographs (12,200 cfs).

5.1.2.3 Site 1

Site 1 was a horsetail - balsam poplar site located just upstream from the Susitna Landing boat ramp near Caswell Creek (RM 62.3). Vegetation on this site has increased in cover and number of stems between 1981 and 1984 reducing bare ground from 79% to 51%. Little change has occurred between 1981 and 1984 for cover of the woody species, balsam poplar and feltleaf willow while horsetail has increased from 10% to 26% cover. Moss and Marchantia spp., a low-growing liverwort, provided 2% cover in 1984. These species sometimes provided sufficient ground cover to keep soil in place, but were not as important at this site as at some other sites.

Balsam poplar stems < 0.4 m tall increased almost six fold between 1981 and 1984 while some individuals grew larger than 0.4-m tall in that time period. The number of feltleaf willow stems < 0.4 m tall decreased dramatically, but the number of stems between 0.4 m and 2.0 m tall was approximately the same as those in the smaller class in 1981. Apparently colonization by feltleaf willow during that time period has been minimal, but existing individuals grew to be of browsable size.

The average height of balsam poplar stems increased from 51 cm to 94 cm while feltleaf willow grew from 67 to 127 cm. The mean age of poplar and willow increased from 5 and 4 years of age respectively to 7 years. The few alder that were present were about 4 years old both times, but few individuals were measured because few were available. Hence, the vegetation seems to have advanced without any major setbacks between 1981 and 1984.

Changes have occurred in this part of the river since 1951. The main flow of the river appeared to have shifted to the west side of the river. This site appeared to have been under water in 1951, although coloration on the photographs indicated that it might have been a submerged bar. On some islands below site 1 on the west side of the river, the river has become more channelized since 1951 allowing the early sites to advance successionally. The main channel moved east of those western islands and deposited material to the east of the channel.

New bars have developed just upstream from site 1 between 1980 and September 16, 1983, as was apparent on those photographs, but these (as well as part of site 1) were inundated by flows similar to the higher flows of August 27, 1983. Increases in vegetation cover were apparent between the 1980 and 1983 photographs. Many individual shrubs, particularly along the sloughs, have been buried by silt but continued growing, indicating that portions of this site were flooded most years.

5.1.2.4 Sites 14, 15, 16

Site 14 was a horsetail-willow site at RM 99 just above the Chulitna confluence and is just across a slough from sites 17 and 15 - 16. The island contained more woody species in its center than along the edges where this site was located. None of the woody species were greater than 40 cm tall in 1981, but balsam poplar and feltleaf willow had 2100 and 15000 stems/ha >40 cm tall in 1984. The total number of stems apparently dropped by a factor of 2 and 3, respectively. The total number of willow stems in other size classes remained about constant. Horsetail provided 60% cover in both 1981 and 1984 while feltleaf willow provided 7% in 1981 and 14% in 1984. Litter cover remained near 10% both years. Other willows increased from negligible amounts in 1981 to 6% in 1984. A sedge similar to Scirpus appeared in some of the other more moist horsetail sites and provided 2 to 5% cover.

This site was present in 1951, but appeared longer and better vegetated in 1980. Comparison of the 1980 and 1983 aerial photographs revealed the island has maintained approximately the same shape, but was now more densely vegetated. This agreed with our observations from 1981 and 1984.

Sites 15 and 16 are located on the same island complex which has several shallow sloughs running through it. Some of these sloughs are vegetated and some are not, depending on their depth. Most of the sloughs flood during high water level (such as 31,000 cfs on August 27, 1983, but not as much at 12,200 cfs on September 16, 1983). Hence, the number and duration of high water events during a summer might directly affect this vegetation.

In particular, one of our permanent transects stretched from relatively high ground to part of a slough. It started in horsetail-willow and went to an area with more of a particular unidentified sedge. This site appeared healthy in July 1984, but when revisited in early September, 1984, the horsetail along the lower reaches of the transect had turned brown, but the rhizomes may still be alive. The willow and sedge appeared healthy. Apparently some high water during the summer killed it. Flooding had also been observed on this island complex during the July 1981 floods.

The number of balsam poplar stems < 40-cm tall increased from 500 stems/ha to over 12,000 stems/ha between 1981 and 1984 while those > 40-cm tall decreased from 10,000 to 1000 stems/ha. There were more smaller stems, but fewer browsable ones on the 1984 visit. This could have resulted from an actual change in population size structure, from sediment deposition making the above-ground portion of the stems shorter, or from inadequate sampling. The total number of browsable stems of feltleaf willow has remained approximately constant, within sampling error. The < 40-cm size class contained few stems in 1981, but as many stems as the browsable classes in 1984. The change in conditions, or persistence of existing conditions, apparently was favoring feltleaf willow browse production. Other species of willow seem to have decreased in density between 1981 and 1984.

Cover followed the same trends as density. Horsetail varied from 43 to 53% cover for the two years, probably within the realm of sampling error. Feltleaf willow exhibited a slight increase from 12 to 20% cover. The other willows decreased from 10% to negligible cover.

The willow and poplar were 2 and 4 years of age in 1981 but alder was not found. Both feltleaf willow and balsam poplar individuals averaged 5 years of age while alder was 3 years old in 1984. This validated the belief that alder became established shortly after willow and balsam poplar. The young age of these woody species in 1984, 3 years after the authors knew that the area was well vegetated, indicated that either riparian events such as flooding or ice scour knocked the vegetation back or perhaps that site conditions were preventing the vigorous growth and maturity of these species.

5.1.2.5 Site 5

Site 5 was a young balsam poplar site somewhat to the east and north of site 8. The dominant change in this site from 1981 to 1984 was that the woody species grew taller. Forty percent of the ground was bare while litter provided 41%, and balsam poplar 27% cover. This was an unusually large amount of litter cover for a juvenile balsam poplar site. Horsetail accounted for 7% cover in 1981. Balsam poplar and willow averaged 63 cm and 78 cm height in 1981, and might have been tall enough for browsing. Poplar was the oldest species averaging 10 years, while feltleaf willow and alder averaged 6 years. The history of this site since 1951 was similar to that already explained for site 8.

5.1.2.6 Site 20

Site 20 was a juvenile balsam poplar stand at mile 97.5 in the middle of a group of shifting gravel bars just below the confluence of the Susitna, Chulitna, and Talkeetna rivers. Difficulty in access to the site among these shifting bars prevented a revisit of it during summer 1984. A helicopter landed the authors in the general vicinity in May 1984 when there was too little water to boat in the area. There was no sign of recent moose activity at the time. In particular, no stems had been browsed that winter. The general complex of islands appears to have grown larger since 1951.

Vegetation in 1981 consisted primarily of balsam poplar with 8% cover and 38,000 stems/ha < 0.4 m tall. Eighty-four percent of the site was bare of vegetation, litter, or cobbles at that time, and an additional 6% consisted of cobbles and gravel. Feltleaf willow and horsetail provided less than 1% cover each.

5.1.2.7 Site 21.

Site 21 was a young balsam poplar site well below Susitna Landing. It was also a site difficult to recognize because of river changes and lack of good landmarks on the island. A similar island was sampled in 1984, but may not have been the same one. Both times bare ground was between 58% and 70%. There were 38,000 stems/ha of balsam poplar < 0.4 m tall in 1981. Horsetail and balsam poplar each covered approximately 11-12% in both years. Both balsam poplar and the few feltleaf willows present were 7 years old while alder was only 4 years old in 1984, further supporting the hypothesis that alder follows willow and balsam poplar in colonizing a site. Balsam poplar was about 65 cm tall and feltleaf willow 73 cm tall in 1984. The site was very sandy and arid.

5.1.2.8 Site 25

Site 25 was a juvenile balsam poplar stand at RM 84.5, just upstream from the Parks Highway Bridge. This was a typical sandy poplar site with 75% bare ground, 5% cobbles, and only 5% litter. Poplar provided 14% cover while horsetail and feltleaf willow provided 3 and 1%, respectively. Densities of poplar were 6,600 browsable stems/ha, but almost 29,000 stems/ha were less then 0.4 m tall. The few willow and alder stems present (less than 300 stems/ha) were also < 0.4 m tall in 1981. By 1984, however, the average heights for balsam poplar and willow were just over 1.2 m, tall enough for browse even in a heavy snowfall winter.

The mean above-ground age for poplars was 9 years, 6 years for feltleaf willow and 4 years for alder. This was a site with deep sedimentation, and underground portions of the stem accounted for 5-10 years additional growth. Overall the poplar did not appear to be browsed very much during the 1983-1984 winter, but had been heavily browsed in the past. The browsed stems were those near alder, and individual stems in the open were browsed less frequently. Some moose tracks were present, but no fresh pellet groups were observed in May 1984.

There were no obvious changes in the shape of the island from 1951 to 1980, and the island had little vegetation in either aerial photograph. However, a strip of taller vegetation which existed on the west side of the island in 1951 had disappeared by 1980. The lower end of the island became more vegetated during this time period, although there was some vegetation in 1951, particularly along the draws. Some established vegetation upstream from site 25 in 1951 was eliminated by 1980. Vegetation appeared denser in 1983 than 1980.

The island has probably been present the entire time between 1951 and 1980, judging from its shape, position, and depth of sands on it. The vegetation was still juvenile either because something was periodically eliminating it or site conditions were prohibiting the maturation of individuals. Excavated poplar stems had become established initially approximately 0.5 m below the present soil surface. That is, approximately

0.5 m of sediment has been locally deposited since the plants germinated 15 to 20 years ago.

5.1.2.9 Site 22

Site 22 was on an early successional island with a complex of several types of vegetation communities near RM 54 (Figure 10). It was located upstream from site 29 but downstream from sites 23 and 24. The woody species were dominated by feltleaf willow and balsam poplar, but horsetail was abundant. Portions of the island were used by gulls for nesting and a very noticeable algal and moss crust on the soil surface indicated the birds deposited significant amounts of nitrogen fertilizer. Alder also occurred in a few areas and probably enriched the nitrogen content in the area.

The higher portions of the site became better vegetated by 1984, but shallow gullies were becoming deeper by erosion. Almost 50% of the sampled area was bare in 1981 while only 13% was bare in 1984. Horsetail cover more than doubled between 1981 and 1984, having 53% cover in the latter year. Moss cover was almost negligible on the first visit, but had increased to 15% cover in 1984. Balsam poplar and feltleaf willow provided similar amounts of vegetation cover both years, but they decreased from 9% cover in 1981 to 3% in 1984. There were approximately 5 times as many stems of poplar as willow in 1981, but all the poplar were less than 0.4 m tall, and all the willow were 0.4-2.0 m tall.

Both willow and poplar were 6 to 7 years old while alder was aged near 5 years. Both dominant species were 1.5 m tall on the average in 1984 and available for browse. Although alder was usually slightly younger than either poplar or willow on these sites, it was usually a larger plant, being both taller and having more breadth.

Less land was generally available for colonization in 1951 in that portion of the river, but the study area appeared above water. Sand bars were just starting to become elevated above the river. By 1980 the right bank of the river near that reach had been eroded, but more bars were forming near site 22 and existing bars were becoming more vegetated. More vegetation was present but gullies appeared more distinct on the 1983 photographs. An island to the east has had the upstream end eroded, but this island has had a "new" bar appear close to it. This new bar has a similar shape. Although the study island had been in existence for a number of years, it was subject to much river action and probably would not reach a mature stage unless the river changed significantly. Although vegetation was developing on the island, gullies seemed to be getting deeper and dissecting the island. Eventually the island might be eroded completely.

5.1.2.10 Site 18

Site 18 was a dryas site on the right side of the river at RM 96 below Talkeetna. It was predominantly a cobbly site with dryas and a few areas of deeper soils where juvenile poplar and horsetail could grow. The site was very similar between 1981 and 1984 although there appeared to be more horsetail and silt in 1984. This site seemed to flood approximately every 5 years, since above-ground ages were 4 to 6 years and below ground ages were 4 to 6 years.

This site was in existence, but relatively bare, in 1951. It contained low vegetation over much of the area with some taller shrubs, such as alder, in 1980 photographs. The 1983 photographs appeared the same as 1980. Since the poplar were so young in the area, vegetation has not been advancing successionally. The site has either been frequently flooded or scoured, or the site has just recently acquired enough sediment over the cobbles for other plants besides dryas to grow, or poplar cannot establish itself on that island. The frequent flooding or scouring hypothesis was favored since all of the protected areas and pockets in the terrain of this site have accumulated relatively deep soil (50 cm). The central sloughs of this site appear to receive frequent flow, as water which overtops the gravel berm at the upstream edge of this area flows into the sloughs.

Areas above and below site 18 have been eroded since 1951, including relatively mature vegetation near the center of the channel. The channels near this site appeared wider in 1980 than in 1951. The Chulitna river has eroded additional area between 1980 and 1983. Since areas near it were being eroded, this site was probably flooded frequently.

This site also provided some interesting insights into browsing, at least for balsam poplar. Individuals that were browsed were generally older and taller than the unbrowsed individuals, even those greater than 0.4-m tall. Snow depths in the area might average 1.5 m, rather than the 0.4 m assumed from a study in Denali, the most useful information available when the study was initiated. This might account for the number of unbrowsed "browsable" stems. The browsed stems also appeared to be away from feltleaf willow or near alder. One interpretation of this was that when moose were near feltleaf willow, they ate willow rather than the poplar, but if they were near alder, they ate poplar rather than alder. (The authors are not proposing that this single observation should lead to the conclusion that moose prefer feltleaf willow over balsam poplar and poplar over alder, but it does support the order of preferences suggested by Wolff (1976), Machida (1979), and others.) Another interpretation was that alder were generally taller than the willow and in small thickets which provided cover for moose, whereas the willow were in more open areas. Moose may have eaten relatively more poplar near alder cover because they stayed there long enough to reduce willow availability to where preference shifted toward poplar.

5.2 Intermediate Successional Stages

5.2.1 General Descriptions

Deposition of sands and silts and/or the deepening of adjacent channels, resulted in the elevation of sites farther above the level of frequent flooding. This plus freedom from disturbance from ice and fast water appeared to be necessary for transition of early successional vegetation to mid-successional stages. These mid-successional types accounted for about one-fifth of vegetated land in the floodplain. Mid-successional vegetation was characterized by thinleaf alder or immature balsam poplar which had developed into tall shrubs or trees. The alder type is the first phase of this mid-successional stage and appeared to last from 15 to 30 years after island stabilization (Figure 15). The immature balsam poplar stands appeared to dominate the vegetation 35 to 55 years after stabilization, but were much less frequent than the alder type.

Total vegetation cover in alder stands averaged 87% (Table 16); thinleaf alder provided 59%, whereas balsam poplar provided only 13% cover. A striking difference between early and mid-successional stages was the reduction of bare ground in mid-successional stands. Litter and bluejoint (Calamagrostis canadensis) covers were 99% and 38%, respectively.

Alder density greatly increased over that of early successional stands (691 up to 6682 stems/ha), whereas balsam poplar declined from 40,000 to 2623 stems/ha (Table 17). Crowding, competition, and preferential browsing by moose may account for some of the reduction of balsam poplar. Alder is a nitrogen-fixing plant which enables it to perform better than balsam poplar on young, infertile soils since nitrogen is frequently limiting growth. Alder may enrich the soil so that other species grow better in later stages. Poplar does not grow well in the shade of the taller alder during this development stage. However, shade tolerant species such as raspberry, prickly rose, and highbush cranberry appeared on these sites.

The average ages of tall shrub-sized thinleaf alder and balsam poplar in alder stands were 20 and 19 years, respectively (Table 18). Because of the cycling that occurs in early successional stages and the fact that most alder stems took root considerably after island stabilization, these islands were probably stabilized 25 to 30 or more years ago. Balsam poplar and alder heights were nearly equal, 7.9,and 7.0 m, respectively in the alder stands. However, observation of many different aged alder stands suggested that once balsam poplar reached the top of alder canopies, the balsam poplar quickly doubled its height, thereby overshadowing the alder and developing into the immature balsam poplar phase of the mid-successional stage. The alder phase was typified by sites 27, 23, 2, and 19.

Balsam poplar dominated the overstory of immature balsam poplar stands, producing 62% cover (Table 19); thinleaf alder provided 40% cover. As in alder stands, there was essentially no bare ground and litter and bluejoint reduction of bare ground in mid-successional stands. Litter and bluejoint (Calamagrostis canadensis) covers were 99% and 38%, respectively.

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Balsam poplar dominated the overstory of immature balsam poplar stands, producing 62% cover (Table 19); thinleaf alder provided 40% cover. As in alder stands, there was essentially no bare ground and litter and bluejoint provided most of the ground cover. Density of balsam poplar and thinleaf alder declined from that found in alder stands since the balsam poplar trees grew larger (Table 21), Sitka alder, however, tripled in density (Table 20). Feltleaf willow decreased from 3559 to 352 stems/ha. Prickly rose and highbush cranberry substantially increased in density (Table 20), and also developed much more robust growth forms (Table 21).

Balsam poplar trees in immature balsam poplar stands averaged 44 years of age (Table 22) and 18 m in height, which was more than double their height in the alder phase. Alder ages were about the same in both the alder and immature balsam poplar phases, suggesting that approximately 20 years is the life expectancy of individual alder stems. Balsam poplars in the immature poplar stands were among the early colonizers of the island, while the alder stems in these sites must be second growth. Heights of alder were also roughly equal between the two phases and it was apparent that thinleaf alder attained a greater height than Sitka alder (Table 22). Immature balsam poplar sites were typified by sites 10, 26, and 12.

White spruce was found as early as the alder phase (34 stems/ha), with the number of individuals only slightly increased in the immature balsam poplar phase (Tables 17 and 20). Age data (Table 22), however, suggest that most white spruce individuals were established sometime after alder stands began developing into the immature balsam poplar phase. This discrepancy could indicate sampling was insufficient to cover stand variability and/or that considerable mortality occurred with young white spruce in this early period of their establishment. Nanson and Beach (1977) has also noticed this phenomenon in British Columbia. Paper birch also was found in both mid-successional phases, but the age differences between phases (Table 18,

22) indicated no increase in the number of individuals as the immature balsam poplar phase developed.

Ice may strongly affect some of the stems in these intermediate sites. The stems are rigid enough that when they get knocked down by ice, they do not spring back as the more resilient stems of the early successional stages do. However, they are not so rigid that they are broken as in later successional stages. The bent stems may then resprout. The site is still basically in the same stage that it was before the ice scour, but it has a younger age structure. For instance, if a 20-year old alder stand were leveled by an ice jam flood, 1-year old stems would be present the next year growing vertically from the horizontal 20-year stems. Hence, the age distribution has been reduced from a mean of 20 years to a mean of 1 year. This may occur repeatedly along the same sections of the river, but it usually occurs only in localized positions where jams occur frequently (Figures 16, 17).

The amount of damage and vegetation stages affected would be determined by the size of the ice jam. For instance, near Whiskers Creek (cross section LRX-7, site 12), jams occur almost every year. The uppermost end of the island has early successional vegetation that gets knocked back and buried rather frequently. An alder stand occurs slightly downstream and portions of it were last leveled nearly 2 decades ago. Further downstream was an immature balsam poplar site with several scarred trees, some scars 2 m above ground, and some trees have several sets of scars from the several times they had been scraped. Repeated scraping may affect the vigor of the plant, but it does not usually cause retrogression to an earlier vegetation stage.

Mid-successional plant communities generally had fewer stems of browse/ha available to moose than horsetail-willow or horsetail-balsam poplar communities, but the diversity of browse was greater with the presence of shade tolerant species such as highbush cranberry, raspberry, and prickly rose (Table 6). Mid-successional communities also provided a mix of forbs which appeared important in the diets of young calves and lactating cows. Both alder and immature balsam poplar stands provided dense hiding and thermal cover. Alder stands, having very low browse densities (excluding alder, a relatively unpalatable species), exhibited extremely heavy utilization of balsam poplar, indicating moose may have been using these stands during severe weather or at other times when they were compelled to linger there.

Sometimes these intermediate sites occurred in very narrow strips around islands and were too small to sample using our techniques. They maximized edge effect for wildlife. More importantly, willow remained relatively abundant in these narrow sites, which had more sunlight entering from the sides than in more intensive intermediate sites. Most of these willow are tall enough to be available to moose even in heavy snowfall years.

5.2.2 Site Histories

5.2.2.1 Alder

5.2.2.1.1 Site 27

Site 27 was an alder site near RM 75.5 below Montana Creek on the west side of the river (Figure 7) that had been flooded and received sediment between 1981 and 1984. There was little understory relative to other alder sites, and the mosses were those associated with early successional sites as opposed to those associated with maturing stands.

Most of the vegetation cover was provided by alder (67%) and balsam poplar (24%). Bluejoint only accounted for 4% cover, whereas in well-developed sites, it provided nearly 50% ground cover. These factors suggested that this site was disturbed more recently than other alder sites we sampled.

The number of balsam poplar stems appeared approximately the same between 1981 and 1984, approximately 2000 browsable stems/ha. There were a similar number of alder stems between the two years, but the size class distribution changed somewhat. There were fewer browsable stems, but more in the 2-4 m tall, > 4-cm dbh category.

The oldest balsam poplar cored was 23 years old with above-ground ages ranging from 10 to 19 years in 1984. Cored alders varied from 14 to 18 years of age while feltleaf willow varied from 12 to 17 years. The largest poplars exhibited good growth in the last 6 years. The uneven age structure, plus the unknown number of years of growth that might be buried by sediment, made it difficult to determine which species came first. Poplar might be somewhat older than the others, and the open nature of the stand permitted reproduction of poplar, a rarity in alder stands. The small size of the stand made edge effect very important, and, in fact, more pellet groups were found near the edge of the stand than toward the middle in May 1984.

Considerable sediment deposition has occurred on or upstream from stand 27 since 1951. It was a relatively unvegetated, but stabilized island in 1951. Areas upstream that were slightly vegetated in 1951 now have vegetation advances beyond the alder stage. No changes occurred between 1980 and 1983, according to photo comparisons.

5.2.2.1.2. Site 23

Site 23 was an alder site near RM 55 and upstream from site 22 on the east side of the river (Figure 10). It was not resampled in 1984 because erosion had almost eliminated it. The vegetation in 1981 was dominated by alder (69% cover), balsam poplar (22%), and bluejoint (58%). There were a few low shrubs and forbs. Approximately 50% more stems of alder than balsam poplar > 4 m tall were present. Other size classes provided less than 670 stems/ha each. All balsam poplar in this stand had been heavily browsed in the past, and numerous dead branches were attached to the trunk.

This site, typical of alder sites, was dominated by 73% cover of thinleaf alder and 53% cover of bluejoint. Balsam poplar provided 22% cover in a site with almost complete vegetation and litter cover. Most thinleaf alder were approximately 25 to 26 years old, but age ranged from 19 to 32 years. Most measured balsam poplar were 25 to 27 years of age although some were near 20 years.

This site had very young vegetation and was almost bare in 1951 which would account for ages < 30 years. The surrounding stable vegetation indicated that this site had been in existence for a period of time, so that the lack of advanced vegetation might have resulted from a catastrophic event such as an ice jam or flood rather than exposure of new land surface by local deposition or downcutting of the river. Erosionn and depositional features were obvious throughout the site in 1981. Most of this area was vegetated with alder by 1980, but the uppermost point still had relatively young vegetation. Apparently the upper point either was disturbed more frequently or site conditions did not permit maturation of the vegetation. By 1983 an island just below this site was being eroded. The slough behind the study area appeared larger in 1984 than in 1981 and was contributing to the erosion.

5.2.2.1.3 Site 2

Site 2 was an alder site, just above the Susitna Landing boat ramp, downstream of Caswell Creek, and just east of site 1 (RM 62.4) (Figure 9). Cover was not remeasured in 1984 because it had not changed much. It had 62% total vegetation cover and complete litter cover in 1981. Alder and bluejoint reedgrass each accounted for 29% cover. Feltleaf willow provided 8% cover, poplar 3%, and horsetail (Equisetum arvense) 4%.

Ages were redetermined to estimate the age of the site rather than the average age of individuals as had been done in 1981. Several individuals were found to be 29 or 30 years old, although most were in the 22 to 26 year old bracket. Several individuals had small annual rings approximately 11 years ago, indicating that 1972-1973 may have been a poor growth year generally or a flooding event caused growth rate reduction in this site. Because rings reflect growing conditions in more than one year, they are not a precise method of indicating when such events occurred. However, there were significant floods with flows greater than 80,000 cfs (Gold Creek) discharge in 1971 and 1972.

Although this site was near site 1, it was on the east side of the river and was not affected by many of the river changes in the area. It was bare ground or early successional vegetation in 1951. Apparently the island had been "stabilized" around 1951, and vegetation has developed uninterrupted since then because the oldest alders are 30 years. Alder is not common in the early stages of vegetation development. Hence, a few years delay after the 1951 photos for alder to become established was reasonable. Also these were above-ground ages so it was possible that several years growth could be buried.

5.2.2.1.4 Site 19

Site 19 was an alder site located at RM 94.5, nearer the east bank than the right bank, but still in the middle of the river. It was abnormally high above the water for an alder stand. There was twice as much willow in the site in 1984 as opposed to 1981 and a significant reduction in the amount of alder. Most of the alders counted in 1981 were > 4 m tall while none was recorded for that size class in 1984. Additionally no balsam poplar were recorded in 1984, but 1500 stems/ha were counted in 1981. Much of this might have resulted from inadvertently locating the transects in different portions of the stand because of the stand's patchy characteristics and the relatively small length of the transects. Sampling error may have accounted for some of the discrepancies.

The oldest individuals were balsam poplar aged 25 to 26 years old. The mean age for poplar was 18 while that for alder was approximately the same.

Changes to this site between 1980 and 1983 were negligible, but vegetation above it had been slightly cut on the upstream end of the east side. A channel on the west had bent further to the west after passing this stand between 1980 and 1983. The channel on the east was taking a more gradual turn to the west in 1983 than it did in 1980. The result was a new surface downstream which appeared vegetated in 1983. The downstream end appeared to be somewhat higher than the upstream end.

5.2.2.2 Immature Balsam Poplar

5.2.2.2.1 Site 10

Site 10 was an immature balsam poplar site at RM 67.5 above Susitna Landing and just a short distance upstream from sites 5-9 (Figure 8). The site was heavily used by beaver, as indicated by the number of balsam poplar cut down. The number of balsam poplar stems in the 2 - 4 m but < 4 cm dbh size class was reduced from 988 to 42 stems/ha between 1981 and 1984. Some of this might be attributable to sampling error, but much of it resulted from beaver as indicated by number of stumps. The visual appearance of the stand differed between 1981 and 1984. Since alder was not a browse species, it was not recounted in 1984 so no comparisons can be made for any changes in it. However, 17 stems/ha of balsam poplar > 4-m tall were found in 1984, but not 1981. Conversely 67 stems/ha were found in 1981 in the 0.4 - 2.0-m class but not in 1984. Apparently the smaller stems have either grown to the larger size class or been eaten but some of the difference could be attributed to sampling. Alder stems totalled almost 3,000 stems/ha in 1981 across all size classes. Feltleaf willow stems decreased from 1000/ha to 83/ha.

The cover measured in 1981 was dominated by 43% alder, 28% balsam poplar and 39% bluejoint. Litter covered 100% of the area. Other species all accounted for less than 2% cover each.

The oldest alder stem cored was 30 years while the average age was 21 in 1984. Most individuals were 16 to 23 years old. The oldest balsam poplar was 42 years old and had its best growth in recent years after it had been released from the alder canopy. The average age was 26 years old with most individuals between 23 and 30 years old. Hence the poplar appear to be 5 to 8 years older than the alder. Many of the cores from this site were difficult to read because of the fineness of the ring boundary. This could result from site conditions or storage problems.

This site was relatively bare in 1951; hence the ages should be close to, but less than 30 years. Only one individual was over 30. Apparently the site became available for colonization around 1951 and has progressed steadily since except for recent beaver activity. Beaver have been observed frequently in the area.

One corner of this island had a patch of stunted vegetation growing on a cobble site. This was probably a dryas site originally, which gradually developed enough soil to support other plants. However, the shallowness of the soils at the site have prevented normal vegetation development. Species include stunted alder and balsam poplar (partly because they are young) as well as a few forbs such as asters and astragalus. The effects of cobble sites might last at least 30 years and might persist much longer unless additional sediments are deposited there.

Since 1951 the main channel of the river has moved to the western side. Apparently the entire site (including the cobble area) became available for colonization. The river changed course before it had deposited sufficient sediment over the cobbles for normal plant growth. In contrast, nearby dryas site 7 might acquire sediment sufficient for better plant growth and succession unless further changes in the river reduces sedimentation or eliminates the site by erosion.

5.2.2.2.2 Site 26

Site 26 was an immature balsam poplar stand at RM 84.6 upstream of the Parks Highway Bridge near site 25, the juvenile balsam poplar site (Figure 6). It contained approximately 400 stems/ha of balsam poplar > 4.0 m tall in 1984, slightly less than in 1981 although this could be a sampling error. The number of alder stems was similar between the two visits, about 4000 browsable stems/ha. Cover values were typical for a site like this: 81% balsam poplar, 60% alder, 7% low shrubs (rose and highbush cranberry), and 23% bluejoint. Several forbs produced less than 1% cover each.

Balsam poplar ages ranged from 40 to 66 years. Several individuals began more rapid growth about 25 to 30 years ago when they were 20 to 25 years old. This was probably when the poplar overtopped the existing alder. The oldest alder cored was 30 years old, but most were around 23 years of age. The rings on the alder were relatively small for the rapid growth rates associated with alder in the open. The relative size of rings and the ages of individuals of the two species supported the hypothesis that the poplar grew more rapidly after overtopping the alder, and that the alder present in an immature balsam poplar stand were probably second growth developing beneath the poplar canopy. No changes in this area were apparent from the aerial photographs other than the general ones described for site 25.

5.2.2.2.3 Site 12

Site 12 was an ice-affected immature balsam poplar site near RM 101.5 near the mouth of Whiskers Creek (Figure 3). Site 12 was in the oldest portion of the island. Upstream from this was an alder site that might have been levelled by ice since 1951. The upper end was either relatively barren or had small willows or balsam poplars growing on it, depending upon how recently it was last flooded.

Because of the variability within the island, 6 transects were used in 1981 and probably covered both the immature balsam poplar and the alder sites, whereas only 2 transects were used in 1984 and were in the older portion of the island. Six transects could not have been located on only the older portion in 1981. Hence, the two sets of data were not directly comparable.

No rose or highbush cranberry were detected in the 1984 transects but they were definitely present at the site. Stem counts for balsam poplar > 4-m tall ranged from 251 stems/ha in 1984 to 791 stems/ha in 1981. The higher count in 1981 probably resulted from including portions of the younger site with higher stem densities.

Vegetation cover at the site consisted of 72% balsam poplar, 32% thinleaf alder, 14% Sitka alder, and a total of only 5% for low shrubs and 2% for bluejoint. This site also had only 80% cover by litter in 1981, a low value for this type vegetation. This site was subject to flooding and sediment deposition both from ice jams and from summer floods. This made it difficult for some species to survive, and also covered some of the litter.

This site appeared to have relatively uniform-aged, developed vegetation on the 1951 aerial photographs except for the upstream end. The 1980 photographs indicated a relatively barren area at the upstream end, intermediate vegetation next, and older vegetation on the downstream end. Willows were bent on the north side of the island in 1981 after an ice jam. Most changes were attributable to ice, but summer flows were responsible for new influx of seeds and the lower limit of vegetation. The older end of the island had scars from ice approximately 2 m above the ground on the north side of the island. When ice scrapes vegetation it destroys the outer bark and cambium, which is essential for new wood growth. Without the cambium to produce new wood, a scar forms, which has no lasting effects on the vegetation structure.

The north side of the island contained most of the ice effects. Many of the alder stems in the alder portion had been bent over then resprouted nearly 20 years ago either from the bent stem or from the surviving root stock if the above-ground stem was too badly damaged (Figure 20). By coring these individuals, an idea of when these catastrophes occurred can be obtained.

Another island occurred just downstream from this study area. This was bare in 1951, but was well vegetated in 1980 with tall willows and alder.

Site 12 was first visited approximately 2 to 3 weeks after an ice jam. Willows on the north side had been bent at approximately a 45 degree angle and may have received a few scrapes, but did not appear otherwise damaged. The upper end appeared barren at first with piles of sediment having been deposited by melting ice blocks and some areas of soil having been pushed by the ice (Figure 17). Closer examination, however, revealed young willow plants poking through the debris. In addition to being matted down, they were also scraped in places, but they were beginning to leaf out. The portions above ground appeared to be only a few years old. However, the presence of even a few stems could make a big difference in successional rates because these stems could propagate vegetatively rather than waiting for seeds to be deposited, germinate, and grow. New shoots were usually stronger than new seedlings.

The oldest balsam poplars on this site were nearly 40 years old although two cored individuals were approximately 64 years old. The last ice jam or major flood to bend the alders appeared to have been nearly 2 decades ago. Some cores on this site were particularly difficult to read, unfortunately. This age estimate was based on the ages of stems resprouted from bent stems and ages to scars on some young plants. Almost all the alder were 10 to 15 years although one 21-year old was cored. The only spruce tree cored on the site was 36 years, with the first 18 years of growth being relatively slow.

5.3 Late Successional Stages

5.3.1 General Descriptions

As the balsam poplar stands matured, white spruce occasionally appeared in the canopy. Mature balsam poplar stands possibly occurred 75 years after island stabilization and extend for another 80 years (Figure 15). Eventually, the balsam poplar becomes decadent leaving space for development of white spruce and paper birch, if no major disturbances interrupt the process. Balsam poplar cannot generally reproduce in the shade of a mature stand. White spruce appears to be shade tolerant and new individuals seem to become established in a random time frame. Paper birch will germinate and grow in the soil on the back sides of uprooted mature trees. Hence, the birch cannot become established until older trees die. The earliest this would occur was probably 70 years after island stabilization, but was more likely 100 years after stabilization. Mature and decadent balsam poplar stands characterize 25 to 40% of the vegetated floodplain while mixed stands of birch and spruce occupy 23 to 32% of the area.

Mature and decadent balsam poplar stands, collectively, averaged 90% total vegetation cover. Balsam poplar trees provided 49% cover, and alder 44% cover, highbush cranberry 21%, prickly rose 15%,and bluejoint 12% (Table 23). Ostrich fern (Matteuccia struthiopteris) was also an important component of the understory (7% cover) not typically found in other floodplain communities. Ostrich fern occurred primarily in mature and decadent balsam poplar stands north of Montana Creek but below Portage Creek. It was used heavily by moose in June. These ferns have not been analyzed nutritionally, but other fern species contain high N levels during early spring growth which could provide a rich source of protein depending upon digestibility of the N compounds in the fern.

Growth characteristics of prickly rose and highbush cranberry, the dominant browse species,were not much different from those in the immature stands (Tables 21, 24), but densities increased from 2556 to 12,361 and from 1093 to 23,555 stems/ha, respectively (Tables 24, 25). This increase in understory was likely a result of reduced competition from the overstory balsam poplar, which experienced natural thinning (from 1045 to 294 stems/ha) as it developed into the mature and decadent stage.

Mature and decadent balsam poplar averaged 26.4 m in height and averaged 98 years in age, according to our 1981 measurements (Table 26). Oldest balsam poplar trees measured in 1984 were approximately 170 years above ground. When one considers delays in sites developing vegetation and the partial burial of trunks, an additional 20 years could be added to the age determined by the core to estimate the time since island stabilization.

Since 1984 samples were biased toward older trunks, an updated mean age could not be reported, but many poplar individuals were 110 to 140 years of age. Some stems of Sitka alder were extremely long-lived relative to alder in other successional stages, and thus the mean age was 50 years.

Paper birch - white spruce communities were characterized by 42% cover by paper birch and 12% cover by white spruce in the overstory (Table 27). Tall shrubs, predominantly thinleaf alder, accounted for 14% cover. Low shrubs, forbs,and grasses provided 40, 44, and 18% cover, respectively.

The average height and apparent age of paper birch trees was 15.5 m and 72 years based on 1981 data (Table). Again, the 1981 estimate was low because of our inability to read rotten trunks, but our 1984 data were biased toward older trees. Ages of mature birch stems have been measured in the 120 to 140 year range in 1984. White spruce averaged 16.2 m and 91 years. thinleaf alder (> 4 m height) averaged 5.5 m and 28 years.

The density of paper birch trees was 227 stems/ha (Table 29). There were 143 white spruce/ha and 1792 alder (all sizes)/ha. Browsable willow, paper birch, highbush cranberry, and prickly rose had densities of 200, 750, 17050, and 16950, respectively. These shrubs were about 1 m tall (Table 30).

Birch-spruce stands had the greatest variation in stand structure of the vegetation types found on the floodplain. There was some evidence that these stands were self-perpetuating. That is, upon decadence the birch overstory falls, making the spruce more susceptible to wind-throw and thereby allowing a paper birch shrub-alder/highbush cranberry-prickly rose community to increase. The shrub community then progresses to the birch-spruce forest condition again. The woody species composition and density of the seral brush phase make it ideal moose habitat, especially as it is interspersed with the more mature forest. Many edges exist between good browse sites and good cover sites.

Because of their extensive coverage, mature and decadent balsam poplar and birch-spruce stands were the major food resource for moose living on the downstream floodplain. A variety of available browse and forbs were present in these stands (Table 6). Densities of willow and balsam poplar were less than in early successional stands, but other species such as highbush cranberry, prickly rose, and birch saplings (in birch-spruce stands) were relatively abundant. The dynamic nature of birch-spruce stands (i.e., the cycling of the stands from overmature overstory to wind-throws and brush fields then back to mature birch-spruce) made this type particularly attractive year-round habitat for moose.

5.3.2 Site Histories

5.3.2.1 Mature and Decadent Balsam Poplar

5.3.2.1.1 Site 3

Site 3 is a mature balsam poplar site above sites 1 and 2, but further to the west near RM 64.1 (Figure 9). Cover of balsam poplar, alder, rose, highbush cranberry, and bluejoint reedgrass increased between 1981 and 1984. This could be an artifact of only running two transects in 1984.

Ages of individual poplar stems reached 127 years with most individuals in the 112 to 119 year bracket. Several individuals grew more slowly after 70 to 90 years, however, one grew better after 53 years. The size of the rings could sometimes be a general indicator of what was happening to a stand, but some individuals might be growing in shade while others took advantage of a canopy opening and grew more rapidly.

Site 3 was part of a larger, forested island in 1951, which had been partly eroded and partly knocked back to bare ground or young vegetation. This resulted from the same westward migration of the river described for sites 1 and 2. Some areas were eroded while other areas were bare ground or early sites in 1983. Mature vegetation on these sites had either been knocked down and flooded away, making room for new succession or the whole area was washed away and new sediment had been locally redeposited. Another forested island to the west of site 3 had been eroded since 1951. The west bank of the island with site 3 was a cut bank with overhanging trunks and branches. The adjacent slough was not safely navigable in May 1984 because of ice, debris, and overhanging trunks.

5.3.2.1.2 Site 24

Site 24 was a mature balsam poplar stand near RM 56 above site 23 (Figure 10). It was dominated by 64% cover of balsam poplar and 54% cover of alder. Highbush cranberry and rose each provided almost 30% cover. Bluejoint and field horsetail (Equisetum arvense) accounted for 5% cover each. As with most of these intermediate and mature sites, litter was everywhere and total vegetation cover was > 90%. Mature poplar trees provided 570 stems/ha. Browsable rose and highbush cranberry provided 24,000 and 27,000 stems/ha while smaller stems of highbush cranberry provided 6900 stems/ha.

Ages on the cored balsam poplars ranged from 69, 145, 152, and 130 years. White spruce was aged 107, 115, 105, 120, and 111 years. The few alders that were cored ranged from 32 to 43 and 45 years. One old birch tree was found to be 149 years old and a young one was aged 7 years. Again, balsam poplar was established 15 to 30 years before the existing spruce entered the site. Alder stems were probably second growth (or later) being reproduced vegetatively or by seed from earlier stock.

The birch tree created a problem since that old a birch tree does not usually occur in similar sites. The most likely explanation was that a birch log or snag bearing a birch sapling washed ashore when the site was becoming established 150 years ago, and the resprout or sapling survived. It was possible that birch seeds might have found a favorable site. Since the site was near the east bank of the river in 1983, the site might not have received much disturbance. Another possible explanation was that the site had become a birch-spruce forest at some time in the past, or at least quite a few individuals were present, then something happened to eliminate the forest, or most of it, except for either some buried seeds or some reproduction. Balsam poplar was then able to colonize the remaining open areas. The soils at the site do not appear old enough to support this hypothesis. This site also had young birch trees growing in the soil on the back sides of roots of uprooted trees.

Much material baove site 24 had been eroded between 1951 and 1980. Additionally, a bar opposite it had migrated downstream. An exteensive slough to its east have become more channelized or narrower and the shores of the sloughs had become vegetated. The river used to be relatively wide at this area, but deposition between 1951 and 1980 on the west side of the river and the downward migration of the bar have constrited the opening. This constriction appears narower in 1983 than in 1980, but the river has broken through the bars on the west side of the river.

5.3.2.1.3 Site 17

Site 17 was a mature balsam poplar site just above the Chulitna confluence at RM 98.8 (Figure 3). It had a relatively dense overstory cover ranging from 62 to 49% in 1981 and 1984, respectively, probably within the realm of sampling error. Some of this variability resulted from using only two transects in 1984. The main species included alder (36 - 49%), ostrich fern (23 to 32%), and devil's club (Echinopanax horridus) (6 - 14%). Some of these species had a very patchy distribution and were found in only some portions of the stand. There was more gymnocarpium in 1981 gut more rose and highbush cranberry in 1984. White spruce accounted for < 5% cover while bluejoint provided 2%. Litter accounted for less cover in 1984 possibly because of floods in July 1981. When the site was visited in early August 1981, water still remained in the low areas and sediment had completely covered all the litter.

Densities were the same between the 2 years sampled although highbush cranberry stem counts decreased from over 13,000 stems/ha to not being recorded in 1984. This was probably related to the patchiness of the site. Highbush cranberry had difficulty reproducing when flooding occurred because it takes 2 years to germinate.

Much of the ostrich fern and some of the devil's club had been eaten when the site was sampled in June 1981. Two moose were observed swimming to and from the island and beds were found in dense patches of the fern. Ostrich fern grows to be over 2 m tall and would probably have been about 1-m tall at this time (early June). Many individuals had less than 20-cm of fronds showing at this time; the rest had been eaten, presumably by the moose. The plant appeared adapted to grazing since new fronds were visible within the crown and were beginning to expand. The crown left a hummock when the fronds died back for the winter. Most moose signs occurred in the portion of the island with the most ostrich fern.

The oldest balsam poplar cored was approximately 139 years with another about 134 years. Most individuals seemed to be approximately 110 to 120 years. The oldest white spruce cored was 143 years while most individuals were about 115 to 125. Hence, it appeared that the spruce were older than the poplar. Several things could have affected this. Spruce annual rings were very easy to read while poplar rings were sometimes difficult. Hence rings could be easily missed on the poplar, resulting in an underestimate of the age. Sometimes the poplar cores crumbled when removing them from the trees. Additionally the poplar have been flooded and partially buried by sediment many times, even after they were relatively mature. Soil pits dug in this and other sites in 1981 revealed multiple alternating layers of organic matter and mineral soil which resulted from floods. This process was observed between June and August 1981. Normally spruce did not become established on site until the amount of flooding and sedimentation had subsided. Hence many more years of poplar growth might be buried under ground than for spruce.

The site appeared to be well vegetated on all three sets of aerial photographs, but the downstream end of the island was being eroded by the Chulitna. This was noticeable even between 1980 and 1983. It had cutbanks on sides parallel to the river. Debris had also been piled across the slough on the Chulitna side. This debris had been overtopped sometime probably in the 1981 floods or 1982 breakup and sediment deposited behind it to form a new island not present in the 1980 photographs, but present in 1983 photographs.

The new island was visited in 1984 and most of the individuals were found to be 2 or 3 years old. Both feltleaf willow and balsam poplar as well as some horsetail were present. This implied that initial establishment may not favor any one species. The different phases of early successional stages that we have observed probably resulted from site conditions or events or interspecific competition that developed with time.

5.3.2.1.4 Site 28

Site 28 was a decadent balsam poplar stand just below Montana Creek and just downstream from site 27, an alder site near RM 75.7 (Figure 7). The overstory was dominated by large balsam poplars, most of which have rotten centers Hence, no accurate ages could be obtained in this site. Some of the larger poplars had broken trunks, several meters above the ground. None of the trees had been uprooted so there was no place for birch seedling germination and establishment.

There were many openings in the canopy with the tree cover providing only 42% cover, but the understory was well-developed. Alder had 43% cover, most of which was in individuals > 4 m tall. The 51% cover of low shrubs was divided among highbush cranberry (34%), rose (12%), ribes (14%), and raspberry (10%). Bluejoint provided 24% cover and forbs 41% cover dominated by ostrich fern (17%) and other species. This well-developed understory prevented any plant species from becoming established except those that were extremely shade tolerant in the early years and that could germinate either under or over a litter layer. Vegetative reproduction was favored in such a site. Densities between 1981 and 1984 were about the same except approximately 22,000 stems/ha of highbush cranberry and 3,000 browsable stems/ha of rose were recorded in 1981. Both species had been browsed during the 1983-1984 winter. This site had not changed on the aerial photographs from 1951 to 1983.

It was not clear why there were so few spruce and no birch on this site since it was obviously very old. The present understory was sufficiently dense that it would be difficult for any kinds of seeds to find a place to germinate and become established, a process which requires mineral soil and sunlight. Since many of the poplars have been broken off part way up the trunk, the mineral soil that their upturned roots usually provide were not present. This breaking of stems rather than uprooting implied winter destruction when the soils were frozen. A winter windstorm could have broken these trunks. The site might have been in a position such that the wind was stronger here than in other similar stands or it was just in a different state of maturation or health. Definitely more of these trees had well-developed heart rot than in any other area we sampled.

Spruce are usually able to invade successional stands as early as the alder stage. Yet all the spruce in this site were only saplings < 2 m tall. Possible explanations for the small spruce population included seed shortage or poor environmental conditions at the stage of maturity when spruce would normally colonize. Seed sources appear to be available upstream, but perhaps winds and currents have never been favorable for dispersal. Suitable conditions for germination and establishment might never have occurred. The authors have no reason to support one hypothesis over the others.

5.3.2.1.5 Site 31

Site 31 was a balsam poplar - white spruce site near RM 63 (Figure 9). The understory was similar to that of a mature balsam poplar site so detailed sampling was not done. Much time was spent exploring this transitional stand and trying to understand how a poplar site developed into a paper birch-white spruce site.

Spruce individuals were able to become established in successional sites before birch trees since spruce saplings occurred as early as the alder stages. Invading birch, however, were a rare occurrence. Young birch trees germinated and grew in the soil on the upturned edge of root crowns of uprooted trees. They did not grow in the shaded, vacant hole, but rather on the soil attached to the roots. This microsite provided both mineral soil and more sunlight than the forest floor. Drainage was probably better here t..n in the hole where the old tree had been. In some sites, almost all uprooted trees had a birch tree growing on them, and birch were found nowhere else in the stand. (The lack of uprooted trees may be the reason for poor invasion in site 28.) Birch trees in some sites (site 11, especially) were growing on pedestals, the original dead tree, providing further evidence that this was how birch invaded sites.

The authors also found one young balsam poplar stem sprouting from another dead root stump. This was the only juvenile poplar we have ever found in the understory of an advanced site. Poplar was very shade intolerant.

The three dead poplar trees that provided a base for the birch trees were about 81, 103, and 124 years old. Poplar that were still living ranged from 98 years to 164 years of age with most cored trees being near 130 years old. The oldest cored spruce tree was approximately 130 years and another was 129 years of age. Most of the other mature trees were approximately 105 to 115 years of age. One old birch tree had at least 65 rings, but had a rotten center, hence, it was probably much older. The young birch stems varied from 1 to 5 years of age while young spruce trees ranged from 15 to 22 years of age. All of these young spruce trees were underneath alder. The ecological significance of this was not clear, but it may be related to nutrient status. The alder may provide a nitrogen rich substrate for nearby plants since it is a nitrogen-fixer.

The site had a cutbank on the east side of the island and comparison of 1951 and 1980 photographs indicates that side of the island had been eroding. The channel had moved to the west side of the island, which was more recently vegetated that the east side. Just upstream from this site was an area that has been logged. It appeared to have been partly logged in 1951, and more so by 1980.

5.3.2.2 Paper Birch - White Spruce

5.3.2.2.1 Site 29

Site 29 was a paper birch - white spruce site near RM 53 below site 22 (Figure 10). The overstory was dominated by 46% birch and 18% spruce cover. Rose and highbush cranberry provided 29 and 36% cover, respectively. Horsetails, mostly _Equisetum arvense_, covered over 50% of the ground. Bluejoint cover increased between 1981 and 1984, while field horsetail decreased. The site was relatively diverse and was very patchy, as was typical of birch-spruce sites.

Birch and spruce had approximately the same number of stems in the > 4-m size class: 235 stems/ha for birch and 288 stems/ha for spruce in 1981. Rose had almost 23000 browsable stems/ha while highbush cranberry had almost 31000 stems/ha in 1981.

The oldest cored birch was almost 170 years old. The other mature birch trees were between 100 and 120 years of age. The oldest measured spruce tree was 124 years with the other specimens' ages near 107 years. The best growth appeared to occur after individuals were 50 to 70 years old, more or less. This was probably the age when a neighbor fell over allowing more sunlight to reach the understory or when this stem broke through the canopy. Poor ring separation could account for the difference of these ages relative to the hypothesis that spruce enters a stand first then birch. The 170-year old birch could be explained similarly to site 24, mature balsam poplar. These spruce trees might be second or third generation or entered the site after the birch had entered. The original spruce trees might have died. In fact, one birch tree was found growing on a spruce log.

This site itself has changed little since 1951 although the shoreline above it has been eroded since then. Significant portions of that shoreline had been eroded between the 1981 and 1984 visits. Erosion is also apparent in comparison of 1980 and 1983 aerial photographs. This site had a very patchy vegetation distribution, which really required more intensive sampling for an accurate description. However, the information was probably adequate for comparing sites. Future comparisons of the same site can be made using permanent transects, thus eliminating a lot of variability encountered with this study.

5.3.2.2.2 Site 11

Site 11 was a closed canopy paper birch - white spruce site near RM 102.1 above Talkeetna (Figure 2). Site 4, in contrast, had an open canopy. The overstory was dominated by 41% cover of birch and 21% cover of spruce. Densities for the two species were similar near 140 stems/ha. Large individuals of alder, > 4 m tall, accounted for 134 stems/ha (both species combined) while there were 534 stems/ha of thinleaf alder and 200 stems/ha of Sitka alder (Alnus sinuata)in the 2-4-m, < 4 cm dbh size class. The two species of alder accounted for 22% cover combined. Other important species included rose, highbush cranberry, ribes, devil's club, bluejoint and Dryopteris dilatata, a fern. Rose and highbush cranberry provided over 9000 and almost 8000 stems/ha in the 0.4-2.0-m size class respectively.

The oldest white spruce cored was 142 years old while the oldest birch was 132 years. The other old spruce ages obtained in 1984 were 103, 110, and 131 while those for birch were 110,119, 129, and 96. Given the errors involved in counting rings, especially for birch, and the small sample size, this was insufficient to state that one species came before the other. Deadfall was abundant in this site, and some of the birch trees were rooted on a pedestal of a previously fallen tree, where they had germinated in the mineral soil on the backsides of roots.

This site had no obvious changes between 1981 and 1984 visits or between 1980 and 1983 aerial photographs. It was on the west side of the channelized portion of the river.

reproduction from adjacent mature trees. Spruce came in seemingly randomly, whereas the initial birch trees invaded more nearly at once when conditions are suitable. When the birch trees are old enough, they might reproduce locally. This might depend on health of individuals or possibly on development of crown openings. The development of individuals was strongly influenced by its neighbors. For instance, most spruce trees grew relatively slowly during their first 30 years, probably suppressed by the balsam poplar overstory.

Site 4 had no apparent vegetation changes since 1951. The earliest aerial photographs had mature vegetation there already. However, intermediate and mature vegetation occurred just east of it across a slough. Between 1951 and 1980, this vegetation was eliminated and bare soil (or almost bare) became available for colonization again, or perhaps for secondary succession. The whole island might have been eroded away then reformed, but based on the constant shape, the elimination of the developed vegetation seemed a better hypothesis.

The river also eroded a sand bar upstream between 1980 and 1983. More water was cutting through the slough adjacent to site 4, making it boatable in 1984 where it was not in 1981. The slough had more water, but did not appear wider than in 1980 (photographs) or 1981 (first visit).

6. CONCEPTUAL MODEL

6.1 General Description

The easiest way to visualize the vegetation dynamics along the .sitna River and potential impacts of a hydroelectric project is to review a conceptual model of vegetation succession as depicted in Figure 18. Each compartment represents a stage in the successional sequence. We recognize that succession is a continuous change, however, points along the time line can be classified to discuss them similarly to vegetation types or colors of the light spectrum. A time line in Figure 15 summarizes when vegetation types may be present and the earliest we feel certain species may enter the site on a "permanent" basis.

The model can be interpreted in either of two ways. One is to visualize a point on the surface of the Susitna floodplain, be it water, bare land, or vegetated land. Locate this type of "land" in the model and this is your starting point. The flow lines from that compartment indicate what can happen to that point and where possible, how long it may take or the probability of a change. The other method of interpretation is to estimate what percentage of the floodplain is in each compartment, initiate disturbances such as flooding, and follow changes that occur in the compartments. A more sophisticated model should incorporate age structures within each compartment to handle the cycling problem to be discussed later. However, the simplified version presented here is sufficient to understand the basics of vegetation succession along the Susitna River.

The first two stages, water and bare ground, are physical locations that are either still under water or have less than 2% vegetation cover. Whether something is under water or not obviously depends on the water level, which is related to the flow. We will assume the flow to be approximately 18,000 cfs at Gold Creek and 119,000 cfs at Susitna Station, the flow at which the 1951 and 1980 aerial photographs were taken and just slightly above the 16 September 1983 photographs. This was probably slightly below a "typical" summer flow which is about 23,000 cfs. The model is primarily intended to conceptualize long-term succession as modified by disturbances such as significant floods, ice effects, and animals, rather than short-term dynamics associated with seasonal water fluctuations.

The 2% level of vegetation cover is being used as the lower limit of vegetation since this seems to be a minimal level for observing the vegetation and is what is using for the Alaska vegetation classification system. Many of the early successional types had approximately 8-10% cover when we first visited them. Sites with only first-year seedlings had <2% cover and appeared unvegetated from a passing boat.

Each of the vegetation stages has already been described as have site histories of our sites as far as we have been able to determine or hypothesize. This information has been synthesized to create the following model.

6.2 Early Successional Stages

6.2.1 Colonization and Seed Dispersal

Initial colonization of a site depends on availability of several factors: land to be colonized, viable seeds, and suitable environmental conditions for germination and establishment. The availability of new land for colonization would depend on lower flows for a year or period of years, degradation of the river, local deposition on a bar or formation of a gravel berm which would deflect the river from a certain area. Since the river appears to be in equilibrium, redistribution of sediment appears to be the most likely method to provide new surface area for colonization that will advance successionally. Lower flows for a few years might allow vegetation to become established, but when flows returned to normal, this vegetation might not be able to survive or to advance successionally (unless the river has downcut in the meantime or some other compensating event has occurred). During flood stages, vegetation would slow flow over islands allowing sediments to settle, which would further elevate the islands.

Viable seed may be available from any plant species at certain periods during the growing season. We will assume that seed or other propagules from non-floodplain species may arrive and germinate, but may not survive the conditions. Hence, we will emphasize propagules of balsam poplar, feltleaf willow (and other willows to a lesser extent), horsetail, alder, white spruce, and paper birch. Life histories of these species have already been discussed, but we will summarize the important features of their seed dispersal, germination, and establishment as related to early colonization.

Alder, birch, and spruce all disperse seeds in fall and throughout winter. Alder seems to invade where poplar, willow, and horsetail have become established. If the site is available for colonization in the spring, alder seeds probably would not reach the site until the following year after the fall seed crop. Occasionally we have seen a birch or spruce juvenile in an early site, but these do not usually survive probably because of heat, disturbances, and low soil fertility and moisture.

Balsam poplar and feltleaf willow are woody species that establish initially. Both produce abundant, nondormant seed which is dispersed in the spring (May and June) primarily by wind and water. These seeds remain viable for only a short time, generally 2 to 4 weeks. They also require abundant moisture for germination and early establishment. Most seed deposition is probably by water since line of newly germinated seedlings occur along high water marks where the water elevations remained relatively constant before receding. On some islands, these linear patterns persist as the plants mature, but on others a more random distribution develops. This latter situation may result from shallow, gentle flooding of the entire island rather than just the edges, or it could result from repeated flooding from various angles and differential survival of individuals.

Wind is important for carrying seeds to the water, but deposition on barren sites is by water. Otherwise, newly established seedlings would be found more toward the centers of islands. These sites usually experience drought after waters recede, and plant establishment is difficult. Wind deposition is considered an unlikely mechanism relative to sheet overflow.

Moisture during establishment is extremely important. Both poplar and willow can develop long roots to maintain access to soil moisture. Poplar roots appear to elongate more rapidly than those of the willow. The arid sandy sites are dominated by balsam poplar, and few other species seem to survive there initially. Other species are more important on sites with finer textures and higher soil moisture. Reproducing poplars outnumber willows on the floodplain and seem to produce more catkins per individual because of the tree's size. This results in more seed sexually. Poplar also occur across a broader spectrum of sites than willow.

Spring seed dispersal appears to coincide with spring floods. As flood waters recede, a concentration of seeds is left, and many of them germinate quickly. New seedlings apparently grow roots rapidly enough to maintain contact with soil moisture. There young seedlings may not survive if higher flows occur later in the summer, depending on flood intensity, depth, and duration. Hence, seedling establishment depends on water levels being higher during spring seed dispersal then during late summer. Usually average July and August water levels are higher than average May and June water levels; therefore, colonization may not occur each year. This seems to agree with our observations since we have not observed any 2 to 5-year old sites. The new island near site 17 was probably formed under unusual circumstances, and we observed juveniles on it in 1984. We observed no seedlings on any sites in 1981, partly because our first visits were in June, too early for seedlings; and our last visits were after the summer floods, which would have destroyed spring seedlings.

Horsetail occurs most abundantly on silt deposits and close to island edges, which may be correlated with high soil moisture levels. These plants may grow either from fragments washed downstream or from spores. The horsetail gametophyte is a small inconspicuous plant that develops from spores produced by the conspicuous sporophyte form. We have not found any horsetail plants that were just established; therefore, we don't know how it colonizes new sites. Searches of the literature and inquiries of other vegetation ecologists in the state have yielded no information on how horsetail colonizes bare soils in this study area. Spores of some horsetail species are often produced in cones, dispersed early in the growing season, and germinate readily on moist soils. This prothallus lives for a few weeks, produces male and female gametophyte which fuse and develop into another sporophyte generation.

6.2.2 Establishment

Propagules of any of these three species, or combinations thereof, are available to any barren area, and can germinate and become "established." Environmental conditions, especially available soil moisture and floods, may control which species survive. This natural selection may be absolute, in that some species can not survive such conditions while others can, or it may result from competitive interactions among the species. One species may be able to survive slightly better, but it then slowly monopolizes resources until it dominates and the other species are suppressed and die. Given different conditions, another species may dominate.

The concept that all species may be available and begin colonizing available sites is based on several observations and assumptions. An island established between 1981 and 1983 near the confluence of the Chulitna had all three species present in 1984. The island probably formed during the high flows in late summer 1981 or possibly during breakup 1982. Both poplar and willow individuals were 2 to 3 years old in 1984. The surface soils were medium textured for this ecosystem, consisting of fine sands and silt. It represented typical soil textures rather than an extreme texture such as cobbles or fine silt. There were microsites on the island where some species were growing more abundantly than other species due either to environmental conditions or to initial differences in seed distribution among species.

Site 8 (Figure 13) changed from a horsetail-willow site to a pure horsetail site between 1981 and 1984 (Figure 14). The willows and poplars that had been there disappeared, but new seedlings, especially of poplar had germinated beneath the horsetail. Site conditions have obviously favored horsetail. Whether willow could not tolerate the conditions or whether it could not compete is uncertain. This site had a fine layer of moss in 1984 which might indicate favorable soil moisture and little disturbance. These two factors could have favored the horsetail over willow.

Site 13 has had both willow and horsetail become more abundant and larger between 1981 and 1984. Its conditions apparently have been favorable for both species. This area has had sediment deposited from ice in recent years instead of being eroded away.

Site 15 was inundated between July 1984 and September 1984, apparently destroying the horsetail in the lower elevations, but willow survived. Elevational differences along the transect are approximately 0.5m. The horsetail was brown and apparently dead when the site was revisited, but the rhizomes may still be alive. This site should be revisited to verify horsetails' fate.

Based on the general successional advancement of sites between 1981 and 1984, the authors believe that the size or type of event that resulted in early successional sites has not reoccurred during the study period (1981-1984). This event could be a flood which eroded some areas and deposited fresh surfaces elsewhere. No vegetation retrogression occurred on any of these sites except possibly the flooding of site 15. Many plant communities in early successional stages developed more ground cover, including a moss layer.

Environmental conditions may prevent vegetation from advancing to a later successional stage. Either low soil moisture availability, high water tables, repeated sedimentation from floods, or other factors may suppress plant vigor. These factors would halt biological improvement of site conditions and invasion of later successional species. Mortality and replacement of individuals may lead to an uneven age structure from 4 to 8 years above ground or 6 to 15 years total. Constant resedimentation may prevent the suitable soil development for more advanced vegetation stages.

Site 25, a juvenile balsam poplar stand upstream of the Parks Highway Bridge, had a similar appearance on aerial photographs in both 1951 and 1984. The soil contained several deposition sequences. Above ground stems averaged 7 years in 1984. Some individuals were possibly approaching 15 to 20 years of age when the years that had been buried are considered. Hence, plants on this site seemed to be stressed and unable to advance successionally. The site does not seem to have advanced and then been wiped out by a flood or ice jam. No ice scars were observed on any stems, and it is a much broader area than is usually damaged by ice deposits. The site seemed stagnated. It is conceivable that this could remain a juvenile poplar site for many more years unless the river changes course and erodes the alluvium or eliminates the flooding events.

Site 1 appears to have been submerged in shallow water during 1951. Hence, the authors believe it might have been available for plant colonization 15 years later (mid 1960's), if not before. This was based on how close the submerged surface appeared to emerging. This required a big assumption on the dynamics of the river, and when the site became available, which makes it a less desirable example than site 25. In 1981, the oldest poplar individuals averaged 7 years above ground. These trees were perhaps 10 to 15 years old if buried stems were counted. Again, the soils showed a long history of deposition, but with finer textures (more silt and fine sand) than deposits at site 25. Vegetation ground cover had developed, but succession seemed somewhat affected by sedimentation compared with that expected for an undisturbed site. Moss was present in some portions of the site. Vegetation on this site does appear to be advancing successionally, in contrast to site 25 which appears to be stagnated.

Site 2 is very near site 1, but is in a sheltered portion of the river. It was barren or had vegetation not visible on the 1951 photograph. It has advanced relatively uninterrupted to the alder stage since 1951. Apparently conditions at this site favored plant succession in contrast to those at sites 25 and 1.

6.2.3 Ice Effects

Ice jams may remove juvenile vegetation by pushing the soil and plants rooted in it (Figure 17). More frequently ice scrapes these individuals, but in many cases their stems are flexible enough to bend without breaking. Sometimes ice jams may push soil and accompanying vegetation into berms. On the island near Whiskers Creek, site 12, a depression was observed where ice removed soil and the berm of soil with most plants still intact (Figure 17). With age, stems lose their flexibility and are more easily damaged by ice jams. The annual ice effects probably slow vegetation succession, keeping it cycling within the early stages. Even a few stems surviving ice-scouring promotes vegetation establishment more rapidly than if plants had to reinvade bare ground. These stems propagate vegetatively, which produces cover more quickly than seedlings. During their early years, vegetatively propagated shoots survive deeper floods better than seedlings because the shoots are taller, sturdier and have better root systems.

6.2.4 Substrate Erosion and Deposition

Both ice jams and summer floods may erode soil and vegetation, pushing succession back to the "water" stage. This happens most often along cut banks, but may also erode gentle slopes, and may occur gradually with many relatively small floods or rapidly with a major flood. This type of disturbance appears to occur more often to advanced (forest) vegetation rather than to early successional sites. Early successional sites frequently have sloping, rather than cut banks, and have been relatively recently been deposited. One would expect continued deposition near these sites in the near future, although local conditions may change from net deposition to net erosion many years from now when the vegetation has matured.

Coarse and fine material appear to be distributed from different causes and are deposited in different locations. Coarse material is eroded and deposited predominantly at lower levels during large summer floods while silts may be redeposited during both large and small summer floods and to some extent in the backwaters behind ice jams. Poplar seems to occur more on the sandier sites, which are most extensive below the confluence of the Susitna and Chulitna Rivers. The Chulitna carries a larger and much coarser sediment load than the middle Susitna. Velocities slow below the confluence, and much sand and gravel is deposited in the complex of bars opposite Talkeetna, although much is still available for deposition further downstream. This sediment load, combined with an apparent change in gradient, produces the wide floodplain and sandy sites suitable for balsam poplar below the confluence.

6.2.3 Winter Ice Cover

Another factor to consider with respect to early successional sites is winter ice cover. Currently, most sites are not flooded during winter because water levels with staging are below summer levels and levels before freeze-up are at an annual low. The vegetated sites are probably covered with an insulating layer of snow, except in wind-blown areas. Where overflows occur, they cause icing and cover the vegetation. Because ice conducts heat better than snow, these plants would be subjected to colder temperatures. Preventing air exchange between the below- and above-ground atmospheres may be the most damaging effect. Roots respire even in winter and air exchange is critical to survival. There are probably tolerance differences among these species which might account for variations in survival to icing effects.

6.3 Intermediate Successional Stages

The intermediate vegetation successional stages studied consisted of alder and immature balsam poplar. General description of these sites have already been presented. Initially, alder seemed to grow more rapidly than either balsam poplar or willow. A 5-year old alder would be about 1.5 m tall while a 5-year old poplar or willow would be only 0.5 m tall. Once a site started advancing successionally, it had potential of reaching the alder stage in 15 to 20 years. It is uncertain whether alder grew more rapidly inherently or whether the other two species' growth rates were retarded by browsing or other conditions. Since alder is a nitrogen-fixing species, it can growth better than poplar and willow in these nutrient-poor soils. Given that early successional sites could cycle within themselves for 30 years or more (see site history for site 15), the alder vegetation stage could dominate anywhere from 15 (very earliest, more likely 20 to 25) to 45 years after a site became available for colonization. Early sites caught in these cycles may have continued cycling until the river changed, this might take one year or decades.

Young alder sites seemed to be flooded at least every few years as indicated by the recent silt deposits at site 28 below Montana Creek. Howe , older sites such as sites 2 and 19, have almost complete litter cover and appeared undisturbed, as indicated by the litter and excellent bluejoint cover. The closed alder canopy limited reproduction to shade tolerant species. Poplar is very shade intolerant, so it is unable to reproduce beneath alder or other later vegetation stages. The shade also limited browse production of the understory, which was associated with low shrub species or young trees.

These sites were dominated by alder probably until the poplar in the canopy became 30 to 50 years old above ground, depending on growth rates. Alder was still important beneath the canopy in these immature balsam poplar sites, but these alder stems were second growth, usually 20 to 30 years old, whereas the dominant poplars were 40-50 years old and originated in the early successional stages. At this stage, poplar usually grew better than alder, whereas alder grew more rapidly than poplar in earlier years of the succession. This resulted from reduced browsing because of plant size and increased soil nitrogen from the alder. Except for the age and species structure of the overstory, both alder and immature balsam poplar sites were very similar.

Alder sites may cycle in age structure because of ice effects. These stems were usually levelled against the ground by ice rather than being bent at a 45 degree angle as happened with younger stems. Sometimes part of the stem was broken. If the stem was merely bent, new shoots sprouted from the bent stem. If it was partly broken, new sprouts could have come from either the root and/or from the stem. Hence, a site with alder ages near 20 years now has 1-year old vertical stems. The mean age of stems was reduced from 20 years to 1 year. All stems this size in the way of the ice will be knocked down, although the ice may not have enough momentum to cross the entire stands. That seemed to have happened by site 12 near Whiskers Creek.

By the time vegetation on a site has reached the intermediate stages; trees, shrubs and grasses have well-developed roots, increasing resistance to ice scouring. Hence, ice effects (aside from trunk scars), are confined to cycling the age structure within the alder stage and to furthering cut bank erosion. Ice affects alder and immature balsam poplar sites similarly, except that ice jams would have to be much larger to knock down the larger trunks in immature balsam poplar stages. However, ice scars on these trees are common, indicating that large jams have occurred.

Beaver occasionally remove select poplar trees from these sites in preference to alder. This may change the age and species structure of the canopy. If enough poplar are removed, it could set succession back to the alder stage, which has too dense a canopy for poplar reproduction. This stage would probably cycle within itself until either some catastrophe, like a flood or ice jam, opened the site or the canopy thinned by death of individuals so other species could invade. If conditions are right, spruce develops in alder stands. If undisturbed, spruce should dominate. Birch may invade on soil on the backsides of roots of fallen trees, thereby forming a mixed forest. The authors have not observed any stands along the Susitna floodplain in the study areas that are dominated by white spruce, but this type occurs in many other northern riparian environments, especially in interior Alaska where they are underlain by permafrost. However, these other locations have few birch-spruce stands, if any.

A more likely result of beaver activity compared to the previous scenario is that the balsam poplar canopy would be thinned, and succession would continue except that a more open canopy would be present. This would allow a more productive understory. Site 10 appears to have reduced poplar densities between 1981 and 1984 because of beaver.

6.4 Late Successional Stages

Late stages consist of mature and decadent balsam poplar, transitional balsam poplar - white spruce, and paper birch - white spruce. Although paper birch - white spruce is the oldest forest type that we have sampled, it is usually considered successional to other types in other environments. The authors have observed evidence of it being self-reproducing, so it could be considered a flood disclimax. Mature poplar stands may develop as early as 70 years after island stabilization, but are probably the dominant stage 90-160 years after stabilization (Figure 15). Birch-spruce types probably dominate from year 200 to year 300 or more.

With age, individual balsam poplar trees and understory alder mature and die, allowing sunlight to reach the lower levels and encouraging rose and highbush cranberry growth in the low shrub layer. These are productive browse sites.

Spruce trees are also present in the mature balsam poplar stages, and will probably survive to the birch-spruce stage. Young spruce trees first develop during the alder stage, but the ages of spruce stems in alder versus immature balsam poplar stages are similar. Hence, the young spruce stems growing in the alder stage do not survive to later successional stages. However, spruce in the immature balsam poplar stage seem to survive, since the spruce ages in the mature and decadent balsam poplar stands are much older. Nanson and Beach (1977) have also observed this same phenomenon in British Columbia. Apparently, either site conditions are not suitable for growth in the alder stage or else the area is still disturbed too much for spruce. Spruce is probably relatively intolerant of sedimentation and flooding, compared with balsam poplar. Because of its shade tolerance, spruce may establish in any of the stages at any time, resulting in an uneven age structure.

As large balsam poplar trees die and are uprooted, the soil on the backside of the upturned roots provide a suitable location for birch seedling establishment. There is mineral soil and more sunlight in these microsites than is available underneath the dense shrub canopy.

The usual successional sequence is from balsam poplar to birch-spruce, which eventually dominate the overstory. There appears to be a discontinuity in the late successional stages, since no real transitional stands between poplar-spruce and birch-spruce have been found. Perhaps a catastrophe, such as a major flood event, or a downcutting of the river has occurred in the last 200 years or more that did not affect the sites that are now birch-spruce, but which did affect all sites younger than that. There has been insufficient time for the new sites to develop to those transitional stages.

An alternate pathway that could occur after the mature balsam poplar stage is for beaver to selectively remove the balsam poplar overstory in mature stands. Beaver have cut down large trees in these sites (Site 17). This would prevent birch from becoming established for lack of a seed bed on open mineral soil. Conceivably, sites affected by beaver could become a white spruce site since spruce is more shade tolerant. It is not clear what the understory composition of this type site would be, but it would probably contain relatively little browse.

Once the birch-spruce stage is reached, it seems to be self-reproducing, at least on a short term basis. As trees die, openings in the canopy allow other trees to grow. Larger canopy openings may allow shrubs to dominate that site. Young birch trees are frequently browsed, as are rose and highbush cranberry. This type of vegetation cycling within patches was particularly evident in site 4.

Several areas of birch-spruce forest have also been logged, and are currently in a shrub stage. Birch reproduction appears sufficient to eventually develop a birch-spruce stand. However, there are many birch stems tall enough for browse, even in a relatively hard winter with deep snows.

As birch-spruce cycles within itself, moss may develop on the forest floor, insulating the soils. This could cause soils to become too cold for birch, and the site could progress to a white or black spruce stage. This has never been observed along portions of the floodplain studied. However, while digging the soil pit in stand 4 in early June 1981, ice lenses were discovered near the surface. Further away from the river, especially on the west side, there are sites that appear to be black spruce sites and bogs. These may be on very old terraces of the river.

A balsam poplar site might advance to a spruce site if the poplars were never uprooted to provide a seedbed for the birch. This might happen at site 27 at a future time. Young spruce are present in the understory, but it is uncertain whether they will mature and dominate the site. Poplar is unable to reproduce in the dense shade of the shrub understory at that site. It is unlikely that birch would take root in the mineral soil on uprooted spruce trees since site conditions would probably have changed to the point where spruce was favored over birch because of soil and environmental conditions. However, this is still open to speculation.

7. PROJECT EFFECTS

Seasonal water levels along the middle and lower river will change with the project in operation although the changes below the Chulitna confluence will be tempered by flow from other rivers. Typical summer flows will be reduced from approximately 23,000 cfs at Gold Creek (mean annual flood 52,000 cfs) to 10,000 cfs (Harza-Ebasco 1984c, 1985). Winter flows will be increased from 3,000 cfs to the 10,000 cfs range. Where ice forms along the river, staging will raise the water levels to correspond to open water flows of 20,000 cfs under natural conditions and 30,000 cfs with project. In a cold winter this could be as high as 50,000 cfs with project. Ice formed at these higher levels may encase vegetation in the middle river. Ice is expected to gently melt rather than forming major jams with the resultant floods afterward. Project operation would greatly reduce natural flow fluctuations throughout the year.

7.1 Geomorphology

7.1.1 Middle River

Project operation would have the effect of greatly reducing natural flow fluctuations throughout the year. Summer flood events would be reduced in severity and frequency. High-flow events would only be notable in the middle river if extreme flooding upstream occurred when the reservoirs were nearly full. Some excess from the reservoirs might then cause higher-than-normal flows in the middle river.

No bedload sediments would reach the middle river from the upper river since they would be trapped in the reservoirs. Fine silts and clays, that could remain in suspension in the reservoir, would continue to pass through the middle river, but they would be too fine to be deposited.

Operation of the project may stop any degradation evolution, which may currently be occurring. The riverbed is expected to develop an armor layer as fine sediments are removed from bed. A small amount of scour may occur downstream of the dams as fine materials are removed. It is expected that this degradation will not exceed aproximately one foot, on the average (Harza-Ebasco 1985). Due to the more uniform flows, the middle river may develop a better defined, narrower channel. Some vegetative encroachment may occur upstream of the maximum ice front progression, which is expected to be between RM 123 and 137. Scour may result in a slightly deeper flow depth at given discharges. Expected morphological changes are shown in table 3.

The upper 15 to 28 miles (depending on the year) of the middle river (above RM 123 to 126) would no longer develop a winter ice cover with-project. Even where the ice cover does form downstream from there, a slow spring meltout is expected to occur rather than a normal breakup drive. The potential for ice jamming and related flooding would be eliminated or reduced and, therefore, channel or bank ice scour would also be expected to be reduced.

7.1.2 Lower River

Due to a lowering of peak annual flows from the middle river, long term aggradation is likely to occur in the first several miles of the lower river below the Susitna-Chulitna confluence. The delta of the Chulitna River would extend further toward the east bank of the Susitna River. However, stabilized middle river flows would eventually develop a river channel through the delta that is better defined than it is under natural conditions (Harza-Ebasco Susitna Joint Venture 1984).

In the lower river, project operations would result in a decrease in the magnitude of changes caused by high-flow events, although this may sometimes be masked by floods generated in the Chulitna or Talkeetna Rivers, or other tributaries. Generally, the result is expected to be a somewhat more stabilized floodplain, decreasing number of subchannels, and increased vegetation cover. Expected with-project morphological changes by reach are summarized in Table 3 (R & M Consultants, Inc. 1982).

Bedload sediment contribution from the middle river would be negligible except during extreme high-flow events. The Chulitna and Talkeetna Rivers would remain the major contributors of bedload sediments at the confluence, and would thus continue to have the major influence on lower river sedimentation and morphology (R & M Consultants, Inc. 1982).

Ice processes in the lower river would remain nearly the same, with a somewhat higher stage due to higher project winter flows and perhaps a slight thickening of the ice cover. The river would melt out somewhat earlier than usual, with no breakup drive. Ice processes would continue to have a lesser effect on river morphology.

7.2 Vegetation

The lower summer flows will have these major effects: (1) more new land will be available for possible colonization and (2) soil moisture levels will be drier, and (3) water levels will fluctuate less. The lower level of existing vegetation appears to be related to flows between the average summer flow (23,000 cfs) and the mean annual flood (52,000 cfs) except in a few locations where ice jams regularly occur. More than 75% of the elevations corresponding to the lower vegetation limit correspond to flows greater than 23,000 cfs, but less than 10% correspond to flows greater than 52,000 cfs. Without ice jams the lower level of vegetation would be expected to coincide with summer flows, assuming all this land is suitable for colonization. Hence, the land surface between levels corresponding to the with-project summer flows and the natural summer flows (Figure 19) could become vegetated, or at least would not be inhibited by floods or other riparian events.

Two factors may prevent or slow colonization with the project operational: (1) unsuitable substrate and (2) poor conditions for germination and establishment of vegetation. Most vegetation that eventually advances successionally becomes established on silty to sandy sites. Cobbly sites are generally colonized by dryas plants, and may eventually acquire enough finer soils to support other vegetation. If these sites do not receive additional sediment, they may retain stunted vegetation for 30 years or more. Finer textured material will be assumed to be an acceptable substrate for immediate colonization, while cobbly areas may take considerably longer to develop the horsetail, balsam poplar, and willow sites that have been described in this report, or may develop different vegetation.

Current vegetation establishment seems to depend on water levels during spring seed dispersal to provide (1) the dispersing mechanism and (2) adequate moisture for germination and early seedling establishment. Without adequate rainfall in June, it is possible that vegetation may become established initially only near the June water line. Higher flows in later years or heavier rainfall may make the area between the with-project and natural summer water lines colonizable. Vegetation could spread vegetatively from the (1) existing vegetation and (2) recently established vegetation colonizing the June waterline to the area between the two, but this would be slow. Our present observations seem to indicate that new vegetation does not colonize all available surfaces each year anyway. The lower flows with project could delay the initial establishment of vegetation, but assuming the substrate has a suitable texture, the new sites will probably become vegetated based on the summer flows.

Winter water levels, however, may cover the surfaces that just became available for colonization. Summer floods are usually of relatively short duration and still permit some aeration of the soils, providing the water is still moving and not stationary. In contrast, ice may exist on the water surface in winter and prevent movement of air between the below- and above-ground atmospheres for several months of the winter. The plants are dormant, but roots are still respiring. If the plants are only partially covered by ice, the portion above the ice may provide access for the roots to the above-ground atmosphere for aeration. If the plant is completely covered, as might occur with newly established individuals, no such escape exists and the treatment is much harsher. This could become the limiting factor to vegetation establishment and development. Existing vegetation will probably tolerate the treatment, but new seedlings will have a difficult time becoming established.

Some invasion may occur at lower levels than the existing vegetation by vegetative propagation, but this would probably be minor. Winter water and ice levels may become the lower limit of vegetation, leaving a strip between the with-project and natural summer water levels that would be covered only by annuals, which are relatively rare in the existing riparian environment. The only place where new vegetation would be expected to establish would be where the winter water or ice level with project would be lower than existing vegetation.

Upstream of the ice front but below the dam, winter and summer water levels will be similar during project operation. Hence, this area would be available for colonization, which would be slow because of the cobble substrate along this stretch of the river.

Without the flood pulses of the present system, vegetation would probably advance unhindered. To see the effect this would have on vegetation, one could use Figure 15 and see how things change with time. Early successional sites would be available for browse probably from years 5 or 7 to years 13 or 15. Alder and balsam poplar would dominate for the next 45 years or so, with relatively little browse in most cases. By age 60 the shrub understory of the mature balsam poplar and later stages would have developed with the rose and highbush cranberry browse. Young paper birch trees would probably become available browse by year 100. The number of available browse twigs in each of these stages was already depicted numerically in Table 6.

7.3 Potential Mitigation Measures

Several approaches could be taken to improve moose browse production. The most successful would probably be logging of mature paper birch - white spruce sites. Existing logged areas produce abundant birch browse as well as rose and highbush cranberry. Birch either sprouts or develops from seed in some areas and reaches browsable height within 5 to 7 years for a normal winter (0.5 m snow depth) and 10 to 20 years for a bad winter depending on site condition, weather, and competition from other plants. The rose and highbush cranberry are present in these sites right after logging and would be available for browse at that time.

Burning could also be used, although no examples have been observed along the river. The nature of riparian habitats generally precludes extensive natural fires. A prescribed fire would require the normal precautions for fire control. Burning would release nutrients to the soil that would not occur with logging. No commercial product results from burning, whereas logging produces marketable timber.

Some of the new land surface available in the summer, but flooded in the winter, might be colonized if the transition from pre-project to with-project conditions were accomplished gradually. If the summer water levels were lowered somewhat to make new areas available for colonization, and the winter levels increased a small amount also, the new vegetation might be able to withstand the first winters. By the time the winter flows reached their normal with-project flows, the vegetation might be large enough to withstand the flooding. This would depend on the slope of the terrain and the height of the plant. This may not be considered a viable mitigation technique because it requires regulating flows for a purpose other than power production.

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TABLES

Table 1
Susitna River Reach Definitions
(Bredthauer and Drage 1932)

River Mile	Average Slope	Predominent Channel Pattern
RM 149 to 144	0.00195	Single channel confined by valley walls. Frequent bedrock control points.
RM 144 to 139	0.00260	Split channel confined by valley wall and terraces.
RM 139 to 129.5	0.00210	Split channel confined occasionally by terraces and valley walls. Main channels, side channels sloughs occupy valley bottom.
RM 129.5 to 119	0.00173	Split channel with occasional tendency to braid. Main channel frequently flows against west valley wall. Subchannels and sloughs occupy east floodplain.
RM 119 to 104	0.00153	Single channel frequently incised and occasional islands.
RM 104 to 95	0.00147	Transition from split channel to braided. Occasionally bounded by terraces. Braided through the confluence with Chulitna and Talkeetna Rivers.
RM 95 to 61	0.00105	Braided with occasional confinement by terraces.
RM 61 to 42	0.00073	Combined patterns: western floodplain braided, eastern floodplain split channel.
RM 42 to 0	0.00030	Split channel with occasional tendency to braid. Deltaic distributary channels begin forming at about RM 20.

Table 2
River Bed Material Size
(Harza-Ebasco Susitna Joint Venture)

Mainstem D_{16}	Mainstem D_{50}	Mainstem D_{90}	Tributary or Slough: Creek or Slough	D_{16}	D_{50}	D_{90}
63	70	79	Portage Creek	14	33	100
			Jack Long Creek	-	-	-
			Slough 22	-	-	-
63	70	79	Slough 21	7	40	96
			Slough 20	-	-	-
39	62	82	Indian River	33	50	86
			Gold Creek	17	36	94
			RM 132.0 Creek	-	-	-
23	51	83	4th of July Creek	14	25	54
10	37	97	Sherman Creek	16	30	70
28	49	95	Slough 9	-	-	-
			RM 128.5 Creek	-	-	-
13	31	80	RM 127.3 Creek	-	-	-
			Skull Creek	10	20	47
			Slough 8	-	-	-
			RM 123.9 Creek	-	-	-
12	37	75	RM 121.0 Creek	7	20	65
			Deadhorse Creek	8	19	55
21	45	110	Little Portage	13	26	63
			McKenzie Creek	9	18	45
5	36	118	Lane Creek	5	13	47
			Lane Slough	-	-	-
21	44	70	Gash Creek	-	-	-
			RM 110.0 Creek	-	-	-
17	40	68	Whiskers Creek	-	-	-

Bed material size is shown as D_{16}, D_{50}, and D_{90} sizes, which, respectively, are the sizes at which 16, 50, and 90 percent (by weight) of the bed material particles are finer.

Particle sizes can be divided into three categories:
Sand - 0.064 mm to 2.0 mm,
Gravel - 2.0 mm to 64.0 mm,
Cobble - 64.0 mm to 256.0 mm.

Table 3. Percent cover on early successional stands[a/] on downstream floodplain of Susitna River, summer 1981.

Category		Mean %
Physical Features		
Water		+
Bare ground		53
Gravel, cobbles		2
Vegetation Categories		
Litter		13
Standing dead		+
Perennial grasses		1
Perennial forbs		25
Mosses		+
Lichens		+
Low shrubs		4
Tall shrubs		+
Trees		8
Total vegetation		38
Vegetation by Species or Genus		
Equisetum variegatum	Variegated horsetail	25
Populus balsamifera	Balsam poplar	8
Salix alaxensis	Feltleaf willow	4
Salix novae-angliae	Tall blueberry willow	1
Salix arbusculoides	Little tree willow	+
Salix sp.	Willow	+
Astragalus sp.	Milk-vetch	+
Hedysarum sp.	Sweet-vetch	+
Calamagrostis canadensis	Bluejoint	+
Eriophorum sp.	Cottongrass	+
Scirpus sp.	Bullrush	+
Alnus tenuifolia	Thinleaf alder	+
Alnus sinuata	Sitka alder	+
Artemisia telesii	Wormwood	+
Nephroma sp.	Nephroma	+

[a/] Early successional stands were numbers 1, 5, 6, 8, 9, 13, 14, 15, 20, 21, 22, and 25 (Figure 5). Number of transects sampled was 42.

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SUSITNA HYDROELECTRIC PROJECT

RIPARIAN VEGETATION SUCCESSION REPORT

Report by

University of Alaska-Fairbanks
Agricultural and Forestry Experiment Station

Under contract to
Harza-Ebasco Susitna Joint Venture

Prepared for
Alaska Power Authority

Draft Report
June 1985

Table 4. Density (stems/ha) of woody species in early vegetation successional stages[a] on downstream floodplain of Susitna River, summer 1981.

				2 - 4 m Tall			
		< .4 m Tall	.4 - 2 m Tall	< 4 cm dbh	> 4 cm dbh	> 4 m Tall	Total
Populus balsamifera	Balsam poplar	38865	1103	40			40008
Alnus sinuata	Sitka alder	8	643	40			691
Salix alaxensis	Feltleaf willow	4929	8643				13572
							572
Salix novae-angliae	Tall blueberry willow	1762	1850	135			3747
Salix arcticus	Arctic willow		48				48
Salix sp.	Willow	305					305
Total		45865	12287	215			58367

[a] Early successional stands were numbers 1, 5, 6, 8, 9, 13, 14, 15, 20, 21, 22, and 25 (Figure 5). Number of transects sampled was 42. Browsable stems were those taller than .4 m but with dbh < 4 cm.

Table 5. Characteristics of woody species in early vegetation succession stands[a/] on downstream floodplain of Susitna River, summer 1981[b/].

		Mean Height (cm)	Mean Length (cm)	Mean Width (cm)	Mean Age	Mean Crown Dominance	Number of Individuals Sampled
Salix alaxensis	Feltleaf willow	60	25	18	5	2	68
Salix novae-angliae	Tall blueberry willow	52	18	12	3	2	24
Salix spp.	Willow	68	31	25	4	2	2
Alnus sinuata	Sitka alder	186	163	145	5	2	12
Alnus tenuifolia	Thinleaf alder	154	100	87	3	2	5
Populus balsamifera	Balsam poplar	44	24	19	6	2	63[b/]

[a/] Early successional stands were numbers 1, 5, 6, 8, 9, 13, 14, 15, 20, 21, 22, and 25 (Figure 5). Number of transects sampled was 42.

[b/] Only 62 observations for height.

Table 6. Density and twig count means by successional stage for browse species. All numbers have been rounded.

Vegetation Stage Species	Density stems/ha	Total Twigs/stem	Pct Twigs Browsed	Available Twigs/ha
Early Successional Stages				
Balsam poplar	1500	2.7	4	4100
Feltleaf willow	4300	4.7	76	14500
Alder				
Balsam poplar	3700	3.5	5	7100
Feltleaf willow	1200	4.6	50	5300
Immature Balsam Poplar				
Tall blueberry willow	170	2.1	34	700
Prickly rose	6000	2.5	3	13500
Highbush cranberry	21000	1.1	19	12500
Mature and Decadent Balsam Poplar				
Prickly rose	16300	6.0	41	98000
Highbush cranberry	11300	5.6	29	63000
Paper Birch-White Spruce				
Paper birch	400	7.8	9	3400
Tall blueberry willow	100	4.8	46	600
Prickly rose	3400	4.7	31	16000
Highbush cranberry	400	1.8	28	200

Table 7. Percent cover for stands dominated by horsetail on downstream floodplain of Susitna River, summer 1981.

CATEGORY (N = 18)	$\bar{X}$	$S_{\bar{X}}$	S^2
BARE GROUND	47.	5.5	553.3
LITTER	8.	1.3	32.2
EQUISETUM ARVENSE	0.	0.2	0.6
EQUISETUM variegatum	41.	5.5	535.0
GRAVEL, COBBLES	1.	0.4	3.6
WATER	0.	0.4	2.4
POPULUS BALSAMIFERA	2.	0.6	5.6
SALIX ALAXENSIS	3.	1.5	38.4
SALIX NOVAE-ANGLIAE	0.	0.3	1.6
UNK WILLOW	0.	0.1	0.1
CALAMAGROSTIS CANADENSIS	0.	0.2	0.6
CAREX	0.	0.1	0.1
GRASS	0.	0.1	0.1
PERENNIAL GRASSES	1.	0.3	2.0
PERENNIAL FORBS	41.	5.5	536.6
LOW SHRUBS	4.	1.6	45.6
TREES	2.	0.6	5.6
TOTAL VEGETATION	46.	5.5	549.5

Table 8. Characteristics of woody species in stands dominated by horsetail on downstream floodplain of Susitna River, summer 1981.

CATEGORY (N = 30)	X	S_X	S²	N
SALIX ALAXENSIS HEIGHT (CM)	55.	6.8	1162.6	25
SALIX ALAXENSIS LENGTH (CM)	16.	2.4	147.6	25
SALIX ALAXENSIS WIDTH (CM)	12.	1.8	84.1	25
SALIX ALAXENSIS AGE	3.	0.3	2.7	25
SALIX ALAXENSIS CROWN DOM	2.	0.1	0.2	25
SALIX NOVAE-ANGLIAE HEIGHT (CM	37.	4.2	278.9	16
SALIX NOVAE-ANGLIAE LENGTH (CM	9.	1.4	31.9	16
SALIX NOVAE-ANGLIAE WIDTH (CM)	6.	0.6	5.2	16
SALIX NOVAE-ANGLIAE AGE	2.	0.3	1.3	16
SALIX NOVAE-ANGLIAE CROWN DOM.	2.	0.	0.	16
SALIX 1 HEIGHT (CM)	54.	0.	0.	1
SALIX 1 LENGTH (CM)	16.	0.	0.	1
SALIX 1 WIDTH (CM)	8.	0.	0.	1
SALIX 1 AGE	5.	0.	0.	1
SALIX 1 CROWN DOM.	2.	0.	0.	1
ALNUS SINUATA HEIGHT (CM)	255.	19.5	760.5	2
ALNUS SINUATA LENGTH (CM)	187.	13.5	364.5	2
ALNUS SINUATA WIDTH (CM)	175.	18.5	684.5	2
ALNUS SINUATA AGE	4.	0.	0.	2
ALNUS SINUATA CROWN DOM.	2.	0.	0.	2
ALNUS TENUIFOLIA HEIGHT (CM)	54.	8.5	144.5	2
ALNUS TENUIFOLIA LENGTH (CM)	22.	3.0	18.0	2
ALNUS TENUIFOLIA WIDTH (CM)	12.	0.	0.	2
ALNUS TENUIFOLIA AGE	3.	0.5	0.5	2
ALNUS TENUIFOLIA CROWN DOM.	2.	0.	0.	2
POPULUS BALSAMIFERA HEIGHT (CM	61.	14.8	3297.9	15
POPULUS BALSAMIFERA LENGTH (CM	32.	12.3	2285.7	15
POPULUS BALSAMIFERA WIDTH (CM)	24.	8.1	986.1	15
POPULUS BALSAMIFERA AGE	5.	0.6	4.6	15
POPULUS BALSAMIFERA CROWN DOM.	2.	0.2	0.5	15

Table 9. Density (stems/ha) of woody species in stands dominated by horsetail on downstream floodplain of Susitna River, summer 1981.

CATEGORY (N = 18)	$\bar{X}$	$S_{\bar{X}}$	S^2
POPULUS BALSAMIFERA <.4M	39.1	11.84	2523.87
POPULUS BALSAMIFERA <4M, >4CM	0.6	0.56	5.56
ALNUS SINUATA 2-4M,<4CM	0.3	0.23	0.92
SALIX ALAXENSIS <.4M	30.6	11.35	2320.37
SALIX ALAXENSIS .4-2.0M	24.7	14.67	3873.18
SALIX NOVAE-ANGLIAE <.4M	12.3	5.15	476.82

Table 10. Percent cover for stands dominated by juvenile balsam poplar on downstream floodplain of Susitna River, summer 1981.

CATEGORY (N = 15)	$\bar{X}$	$S_{\bar{X}}$	S^2	N
BARE GROUND	71.	4.9	366.1	15
LITTER	11.	4.3	276.7	15
STANDING DEAD	0.	0.1	0.2	15
EQUISETUM spp.	0.	0.1	0.2	15
EQUISETUM variegatum	5.	1.8	46.8	15
GRAVEL, COBBLES	3.	1.4	31.3	15
EPILOBIUM LATIFOLIUM	0.	0.1	0.2	15
POPULUS BALSAMIFERA	14.	2.3	76.6	15
ALNUS SINUATA	0.	0.2	0.7	15
SALIX ALAXENSIS	1.	0.5	3.7	15
ASTRAGALUS OR OXYTROPIS	1.	0.3	1.0	15
GRASS	1.	0.3	1.4	15
PERENNIAL GRASSES	1.	0.3	1.4	15
PERENNIAL FORBS	5.	1.7	45.3	15
LOW SHRUBS	1.	0.5	3.7	15
TALL SHRUBS	0.	0.2	0.7	15
TREES	14.	2.3	76.6	15
TOTAL VEGETATION	20.	3.1	148.5	15

Table 11. Characteristics of woody species in stands dominated by juvenile balsam poplar on downstream floodplain of Susitna River, summer 1981.

CATEGORY (N = 30)	$\bar{X}$	$S_{\bar{X}}$	S^2	N
SALIX ALAXENSIS HEIGHT (CM)	51.	5.0	614.1	25
SALIX ALAXENSIS LENGTH (CM)	29.	4.5	506.7	25
SALIX ALAXENSIS WIDTH (CM)	21.	3.3	266.4	25
SALIX ALAXENSIS AGE	5.	0.5	5.9	25
SALIX ALAXENSIS CROWN DOM.	2.	0.2	1.5	25
SALIX NOVAE-ANGLIAE HEIGHT (CM	81.	0.	0.	1
SALIX NOVAE-ANGLIAE LENGTH (CM	59.	0.	0.	1
SALIX NOVAE-ANGLIAE WIDTH (CM)	30.	0.	0.	1
SALIX NOVAE-ANGLIAE AGE	4.	0.	0.	1
SALIX NOVAE-ANGLIAE CROWN DOM.	2.	0.	0.	1
ALNUS SINUATA HEIGHT (CM)	197.	20.6	2558.4	6
ALNUS SINUATA LENGTH (CM)	214.	25.3	3854.2	6
ALNUS SINUATA WIDTH (CM)	190.	24.4	3578.6	6
ALNUS SINUATA AGE	6.	1.3	10.3	6
ALNUS SINUATA CROWN DOM.	2.	0.2	0.3	6
ALNUS TENUIFOLIA HEIGHT (CM)	330.	0.	0.	1
ALNUS TENUIFOLIA LENGTH (CM)	335.	0.	0.	1
ALNUS TENUIFOLIA WIDTH (CM)	325.	0.	0.	1
ALNUS TENUIFOLIA AGE	5.	0.	0.	1
ALNUS TENUIFOLIA CROWN DOM.	1.	0.	0.	1
POPULUS BALSAMIFERA HEIGHT (CM	32.	5.7	988.9	30
POPULUS BALSAMIFERA LENGTH (CM	22.	3.2	308.6	30
POPULUS BALSAMIFERA WIDTH (CM)	17.	2.2	140.7	30
POPULUS BALSAMIFERA AGE	7.	0.6	12.1	30
POPULUS BALSAMIFERA CROWN DOM.	2.	0.2	1.7	30

able 12. Density (stems/ha) of woody species in stands dominated by juvenile balsam poplar on downstream floodplain of Susitna River, summer 1981.

ORY (N = 15)	$\bar{X}$	$S_{\bar{X}}$	S^2
JS BALSAMIFERA <.4M	190.6	38.44	22168.97
.4-2.0M	5.3	4.13	256.07
SINUATA <.4M	0.1	0.07	0.07
SINUATA .4-2.0M	0.1	0.07	0.07
ALAXENSIS <.4M	4.7	2.70	109.52
ALAXENSIS .4-2.0M	5.3	2.95	130.50
NOVAE-ANGLIAE .4-2.0M	0.7	0.53	4.24

Table 13. Percent cover for stands dominated by feltleaf willow on downstream floodplain of Susitna River, summer 1981.

CATEGORY (N = 9)	$\bar{X}$	$S_{\bar{X}}$	S^2	N
BARE GROUND	35.	6.9	426.4	9
LITTER	29.	8.1	596.1	9.
STANDING DEAD	0.	0.2	0.3	9
EQUISETUM variegatum	25.	6.2	346.2	9
LICHENS	1.	0.6	2.8	9
NEPHROMA	0.	0.4	1.2	9
MOSS	1.	0.4	1.3	9
MOSS A	0.	0.4	1.2	9
MOSS B	0.	0.2	0.3	9
POPULUS BALSAMIFERA	9.	2.2	44.3	9
ALNUS TENUIFOLIA	0.	0.4	1.2	9
ALNUS SINUATA	1.	0.6	3.5	9
SALIX SPP.	0.	0.2	0.3	9
SALIX ALAXENSIS	9.	1.7	25.1	9
SALIX ARBUSCULOIDES	0.	0.2	0.3	9
SALIX NOVAE-ANGLIAE	3.	1.4	16.7	9
UNK WILLOW	1.	0.4	1.3	9
ARTEMISIA TILESII	0.	0.2	0.3	9
ASTRAGALUS OR OXYTROPIS	0.	0.4	1.2	9
HEDYSARUM	0.	0.2	0.3	9
CALAMAGROSTIS CANADENSIS	1.	0.6	2.8	9
GRASS	1.	0.4	1.3	9
FINE GRASS, ST 22	0.	0.2	0.3	9
GROUND LAYER - MOSSES AND LICH	2.	1.1	10.9	9
PERENNIAL GRASSES	2.	0.6	3.7	9
PERENNIAL FORBS	26.	6.1	330.8	9
LOW SHRUBS	12.	2.8	68.1	9
TALL SHRUBS	1.	0.7	4.0	9
TREES	9.	2.2	44.3	9
TOTAL VEGETATION	48.	5.7	288.4	9

Table 14. Characteristics of woody species in stands dominated by feltleaf willow on downstream floodplain of Susitna River, summer 1981.

CATEGORY (N = 22)	$\bar{X}$	$S_{\bar{X}}$	S^2	N
SALIX ALAXENSIS HEIGHT (CM)	79.	10.4	1958.8	18
SALIX ALAXENSIS LENGTH (CM)	31.	3.2	181.5	18
SALIX ALAXENSIS WIDTH (CM)	23.	2.3	92.7	18
SALIX ALAXENSIS AGE	6.	0.5	5.2	18
SALIX ALAXENSIS CROWN DOM.	2.	0.2	0.9	18
SALIX NOVAE-ANGLIAE HEIGHT (CM	83.	17.0	2026.0	7
SALIX NOVAE-ANGLIAE LENGTH (CM	33.	4.2	122.7	7
SALIX NOVAE-ANGLIAE WIDTH (CM)	23.	4.5	139.6	7
SALIX NOVAE-ANGLIAE AGE	4.	0.4	1.3	7
SALIX NOVAE-ANGLIAE CROWN DOM.	2.	0.2	0.2	7
SALIX 1 HEIGHT (CM)	73.	16.3	1600.2	6
SALIX 1 LENGTH (CM)	34.	9.2	504.6	6
SALIX 1 WIDTH (CM)	35.	7.0	291.1	6
SALIX 1 AGE	6.	0.9	4.4	6
SALIX 1 CROWN DOM.	2.	0.2	0.3	6
SALIX 3 HEIGHT (CM)	68.	9.0	162.0	2
SALIX 3 LENGTH (CM)	31.	4.0	32.0	2
SALIX 3 WIDTH (CM)	25.	0.	0.	2
SALIX 3 AGE	4.	1.0	2.0	2
SALIX 3 CROWN DOM.	2.	0.	0.	2
ALNUS SINUATA HEIGHT (CM)	134.	32.2	4144.3	4
ALNUS SINUATA LENGTH (CM)	74.	24.9	2475.0	4
ALNUS SINUATA WIDTH (CM)	63.	24.4	2374.3	4
ALNUS SINUATA AGE	3.	0.3	0.3	4
ALNUS SINUATA CROWN DOM.	2.	0.	0.	4
ALNUS TENUIFOLIA HEIGHT (CM)	167.	91.5	16744.5	2
ALNUS TENUIFOLIA LENGTH (CM)	62.	28.5	1624.5	2
ALNUS TENUIFOLIA WIDTH (CM)	44.	16.0	512.0	2
ALNUS TENUIFOLIA AGE	3.	0.	0.	2
ALNUS TENUIFOLIA CROWN DOM.	3.	1.0	2.0	2
POPULUS BALSAMIFERA HEIGHT (CM	49.	10.0	1700.6	17
POPULUS BALSAMIFERA LENGTH (CM	22.	3.4	210.6	18
POPULUS BALSAMIFERA WIDTH (CM)	18.	2.3	92.3	18
POPULUS BALSAMIFERA AGE	7.	0.8	12.5	18
POPULUS BALSAMIFERA CROWN DOM.	2.	0.2	0.7	18

Table 15. Density (stems/ha) of woody species in stands dominated by feltleaf willow on downstream floodplain of Susitna River, summer 1981.

CATEGORY (N = 9)	$\bar{X}$	$S_{\bar{X}}$	S^2
POPULUS BALSAMIFERA <.4M	148.2	46.54	19493.19
POBA .4-2.0M	6.7	6.67	400.00
ALNUS SINUATA .4-2.0M	8.9	7.90	562.36
SALIX ALAXENSIS .4-2.0M	62.9	7.68	531.11
BETULA PAPYRIFERA .4-2.0M	2.7	2.22	44.44
BETULA PAPYRIFERA 2-4M,>4CM	1.9	1.65	24.61
SALIX NOVAE-ANGLIAE .4-2.0M	18.7	12.46	1397.00
Salix arbusculoides .4-2.0 M	0.7	0.37	1.25

Table 16. Percent cover in alder stands[a/] on downstream floodplain of Susitna River, summer 1981.

Category		Mean %
Physical Features		
Bare ground		1
Litter		99
Vegetation Categories		
Standing dead		+
Perennial grasses		38
Perennial forbs		11
Mosses		+
Lichens		+
Low shrubs		6
Tall shrubs		60
Trees		13
Total vegetation		87
Vegetation by Species or Genus		
Calamagrostis canadensis	Bluejoint	38
Alnus tenuifolia	Thinleaf alder	59
Alnus sinuata	Sitka alder	3
Viburnum edule	Highbush cranberry	1
Epilobium angustifolium	Fireweed	3
Populus balsamifera	Balsam poplar	13
Artemisia tilesii	Wormwood	3
Salix alaxensis	Feltleaf willow	5
Salix novae-angliae	Tall blueberry willow	+
Salix sp.	Willow	+
Stellaria sp.	Starwort	+
Epilobium latifolium	Dwarf fireweed	+
Rosa acicularis	Prickly rose	+
Ribes spp.	Currant	+
Hedysarum sp.	Sweet-vetch	+
Rubus arcticus	Nagoonberry	+
Rubus idaeus	Raspberry	+
Trientalis europaea	Arctic starflower	+
Galium sp.	Bedstraw	+
Poa sp.	Bluegrass	+

a/ Alder stands were numbers 2, 19, 23, and 27 (Figure 5). Number of transects sampled was 20.

Table 17. Density (stems/ha) of woody species in alder stands[a] on downstream floodplain of Susitna River, summer 1981.

		< .4 m Tall	.4 - 2 m Tall	< 4 cm dbh	> 4 cm dbh	> 4 m Tall	Total
Populus balsamifera	Balsam poplar	867	900	417	42	397	2623
Alnus tenuifolia	Thinleaf alder	483	1850	633	983	2317	6266
Alnus sinuata	Sitka alder		133	33		250	416
Salix alaxensis	Feltleaf willow	617	2517	167	133	125	3559
Picea glauca	White spruce	17	17				34
Echinopanax horridum	Devil's club		133				133
Rubus idaeus	Raspberry	967	200				1167
Rosa acicularis	Prickly rose	517	117				634
Viburnum edule	Highbush cranberry		467				467
Salix novae-angliae	Tall blueberry willow		83				83
Ribes triste	American red currant	1133					1133
Salix sp.	Willow	783					783
Total		5384	6417	1250	1158	3089	17298

[a] Alder stands were numbers 2, 19, 23, and 27 (Figure 5). Number of transects sampled was 20. Browsable stems were those taller than .4 m but with dbh < 4 cm.

Table 18. Characteristics of trees and tall shrubs in alder stands [a/] on downstream floodplain of Susitna River, summer 1981.

		Mean Height (m)	Mean dbh (cm)	Mean Age	Mean Crown Dominance	Number of Individuals Sampled
Populus balsamifera	Balsam poplar	7.9	7.2	19	2	28[b/]
Alnus tenuifolia	Thinleaf alder	7.0	7.3	20	2	40[c/]
Alnus sinuata	Sitka alder	3.9	3.4	17	5	4
Betula papyrifera	Paper birch	4.9	4.6	13	4	4
Picea glauca	White spruce	4.7	5.0	11	4	9[d/]

[a/] Alder stands were numbers 2, 19, 23, and 27 (Figure 5). Number of transects sampled was 20.

[b/] Only 27 observations for dbh.

[c/] Only 37 observations for age.

[d/] Only 7 observations for dbh.

Table 19. Percent cover in immature balsam poplar stands[a] on downstream floodplain, summer 1981.

Category		Mean %
Physical Features		
Vegetation Categories		
Litter		95
Standing dead		+
Perennial grasses		23
Perennial forbs		9
Mosses		+
Low shrubs		6
Tall shrubs		48
Trees		62
Total vegetation		91
Vegetation by Species or Genus		
Populus balsamifera	Balsam poplar	62
Alnus tenuifolia	Thinleaf alder	40
Alnus sinuata	Sitka alder	8
Calamagrostis canadensis	Bluejoint	23
Viburnum edule	Highbush cranberry	3
Artemisia tilesii	Wormwood	3
Heracleum lanatum	Cow parsnip	1
Mertensia paniculata	Tall bluebell	1
Rosa acicularis	Prickly rose	3
Picea glauca	White spruce	+
Salix novae-angliae	Tall blueberry willow	+
Pyrola secunda	One-sided wintergreen	+
Pyrola sp.	Wintergreen	+
Rubus idaeus	Raspberry	+
Sanguisorba stipulata	Sitka burnet	+
Galium sp.	Bedstraw	+
Matteuccia struthiopteris	Ostrich fern	+
Streptopus amplexicaulis	Cucumber-root	+

[a] Immature balsam poplar stands were numbers 10, 12, and 26 (Figure 5). Number of transects sampled was 18.

Table 20. Density (stems/ha) of woody species in immature balsam poplar stands[a] on downstream floodplain, summer 1981.

				2 - 4 m Tall			
		< .4 m Tall	.4 - 2 m Tall	< 4 cm dbh	> 4 cm dbh	> 4 m Tall	Total
Populus balsamifera	Balsam poplar		19	407	619		1045
Alnus tenuifolia	Thinleaf alder	74	1759	1704	56	1472	5065
Alnus sinuata	Sitka alder		907	426		19	1352
Salix alaxensis	Feltleaf alder		352				352
Salix sp.	Willow		148				148
Picea glauca	White spruce		37				37
Rubus idaeus	Raspberry	1185					1185
Rosa acicularis	Prickly rose	1037	1519				2556
Viburnum edule	Highbush cranberry	630	463				1093
Salix novae-angliae	Tall blueberry willow		37				37
Ribes sp.	Currant	759					759
Total		3685	5241	2537	675	1491	13629

[a] Immature balsam poplar stands were numbers 10, 12, and 26 (Figure 5). Number of transects sampled was 18. Browsable stems were those taller than .4 m but less than 4 cm dbh.

Table 21. Characteristics of woody species in immature balsam poplar stands[a/] on downstream floodplain of Susitna River, summer 1981.

		Mean Height (cm)	Mean Length (cm)	Mean Width (cm)	Mean Age	Mean Crown Dominance	Number of Individuals Sampled
Salix novae-angliae	Feltleaf willow	125	53	45	9	6	8
Ribes sp.	Currant	48	35	35	3	7	1
Rubus idaeus	Raspberry	35	29	21	1	7	6
Betula papyrifera	Paper birch	102	25	22	-	6	1[b/]
Picea glauca	White spruce	10	10	7	2	7	1
Alnus sinuata	Sitka alder	181	153	104	8	6	17[c/]
Alnus tenuifolia	Thinleaf alder	139	73	43	6	6	32[d/]
Populus balsamifera	Balsam poplar	182	63	39	15	6	8
Rosa acicularis	Prickly rose	56	40	32	2	6	29
Viburnum edule	Highbush cranberry	94	69	51	5	6	21

a/ Immature balsam poplar stands were numbers 10, 12, and 26 (Figure 5). Number of transects sampled was 18.

b/ No observations for age.

c/ Only 13 observations for age.

d/ Only 31 observations for age.

Table 22. Characteristics of trees and tall shrubs in immature balsam poplar stands[a/] on downstream floodplain of Susitna River, summer 1981.

		Mean Height (m)	Mean dbh (cm)	Mean Age	Mean Crown Dominance	Number of Individuals Sampled
Populus balsamifera	Balsam poplar	17.7	24.8	44	2	36[b/]
Alnus tenuifolia	Thinleaf alder	6.6	6.9	22	4	32[c/]
Alnus sinuata	Sitka alder	5.1	8.5	22	5	3[d/]
Betula papyrifera	Paper birch	6.2	12.4	43	4	1[e/]
Picea glauca	White spruce	2.6	--	13	6	1[f/]

a/ Immature balsam poplar stands were numbers 10, 12, and 26 (Figure 5). Number of transects sampled was 18.

b/ Only 35 observations for crown dominance.

c/ Only 31 observations for age.

d/ Have 4 observations for age.

e/ Have 2 observations for height.

f/ No observations for dbh.

Table 23. Percent cover in mature and decadent balsam poplar stands[a/] on downstream floodplain, summer 1981.

Category		Mean %
Vegetation Categories		
Litter		92
Standing dead		+
Perennial grasses		12
Perennial forbs		23
Mosses		+
Low shrubs		36
Tall shrubs		43
Trees		50
Total vegetation		90
Vegetation by Species or Genus		
Populus balsamifera	Balsam poplar	49
Alnus tenuifolia	Thinleaf alder	41
Alnus sinuata	Sitka alder	3
Viburnum edule	Highbush cranberry	21
Rosa acicularis	Prickly rose	15
Calamagrostis canadensis	Bluejoint	12
Ribes spp.	Currant	3
Mertensia paniculata	Tall bluebell	2
Echinopanax horridum	Devil's club	1
Rubus idaeus	Raspberry	4
Dryopteris dilatata	Spinulose shield-fern	1
Gymnocarpium sp.	Oak-fern	5
Matteuccia struthiopteris	Ostrich fern	7
Streptopus amplexicaulis	Cucumber-root	1
Picea glauca	White spruce	1
Cornus canadensis	Bunchberry	+
Heracleum lanatum	Cow parsnip	+
Pyrola sp.	Wintergreen	+
Trientalis europaea	Arctic starflower	+
Galium sp.	Bedstraw	+

[a/] Mature and decadent balsam poplar stands were numbers 3, 17, 24, and 28 (Figure 5). Number of transects sampled was 24.

Table 24. Characteristics of woody species in mature and decadent balsam poplar stands[a/] on downstream floodplain of Susitna River, summer 1981.

		Mean Height (cm)	Mean Length (cm)	Mean Width (cm)	Mean Age	Mean Crown Dominance	Number of Individuals Sampled
Ribes triste	American red currant	38	29	18	2	7	16
Ribes sp.	Currant	50	45	25	3	7	8
Rubus idaeus	Raspberry	65	45	29	1	7	26[b/]
Alnus sinuata	Sitka alder	248	121	87	9	6	8
Alnus tenuifolia	Thinleaf alder	205	78	53	6	6	20
Rosa acicularis	Prickly rose	65	43	31	2	6	48
Viburnum edule	Highbush cranberry	81	45	30	4	6	48

a/ Mature and decadent balsam poplar stands were numbers 3, 17, 24, and 28 (Figure 5). Number of transects sampled was 24.

b/ Only 24 observations for age.

Table 24. Characteristics of woody species in mature and decadent balsam poplar stands[a/] on downstream floodplain of Susitna River, summer 1981.

		Mean Height (cm)	Mean Length (cm)	Mean Width (cm)	Mean Age	Mean Crown Dominance	Number of Individuals Sampled
Ribes triste	American red currant	38	29	18	2	7	16
Ribes sp.	Currant	50	45	25	3	7	8
Rubus idaeus	Raspberry	65	45	29	1	7	26[b/]
Alnus sinuata	Sitka alder	248	121	87	9	6	8
Alnus tenuifolia	Thinleaf alder	205	78	53	6	6	20
Rosa acicularis	Prickly rose	65	43	31	2	6	48
Viburnum edule	Highbush cranberry	81	45	30	4	6	48

a/ Mature and decadent balsam poplar stands were numbers 3, 17, 24, and 28 (Figure 5). Number of transects sampled was 24.

b/ Only 24 observations for age.

		< .4 m Tall	.4 - 2 m Tall	2 - 4 m Tall < 4 cm dbh	2 - 4 m Tall > 4 cm dbh	> 4 m Tall	Total
<u>Populus balsamifera</u>	Balsam poplar					294	294
<u>Alnus tenuifolia</u>	Thinleaf alder		1917	2236	14	674	4841
<u>Alnus sinuata</u>	Sitka alder		111	278	7	7	403
<u>Picea glauca</u>	White spruce					3	3
<u>Echinopanax horridum</u>	Devil's club	14	1014				1028
<u>Rubus idaeus</u>	Raspberry	2184	3931				6115
<u>Rosa acicularis</u>	Prickly rose	1611	10750				12361
<u>Viburnum edule</u>	Highbush cranberry	1722	21833				23555
<u>Ribes triste</u>	American red currant	6569					6569
Total		12100	39556	2514	21	978	55169

a/ Mature and decadent balsam poplar stands were numbers 3, 17, 24, and 28 (Figure 5). Number of transects was 24. Browsable stems were those taller than 0.4 m but with less than 4 cm dbh.

Table 36. Characteristics of trees and tall shrubs in mature and decadent balsam poplar stands[a/] on downstream floodplain of Susitna River, summer 1981.

		Mean Height (m)	Mean dbh (cm)	Mean Age	Mean Crown Dominance	Number of Individuals Sampled
Populus balsamifera	Balsam poplar	26.4	53.2	98	2	40[b/]
Alnus tenuifolia	Thinleaf alder	7.1	7.4	28	5	42[c/]
Alnus sinuata	Sitka alder	5.3	16.6	50	5	2[d/]
Betula papyrifera	Paper birch	14.2	23.6	63	2	7[e/]
Picea glauca	White spruce	14.0	23.8	94	3	16[f/]

a/ Mature and decadent balsam poplar stands were numbers 3, 17, 24, and 28 (Figure 5). Number of transects sampled was 24.

b/ Only 33 observations for age and 38 for crown dominance.

c/ Only 32 observations for age.

d/ Only 1 observation for crown dominance.

e/ Only 6 observations for age and crown dominance.

f/ Only 14 observations for age.

Table 27. Percent cover in birch-spruce stands[a] on downstream floodplain, summer 1981.

Category		Mean %
<u>Vegetation Categories</u>		
Litter		100
Standing dead		+
Perennial grasses		18
Perennial forbs		44
Mosses		1
Low shrubs		40
Tall shrubs		14
Trees		52
Total vegetation		93
<u>Vegetation by Species or Genus</u>		
Betula papyrifera	Paper birch	42
Picea glauca	White spruce	12
Alnus tenuifolia	Thinleaf alder	10
Alnus sinuata	Sitka alder	5
Viburnum edule	Highbush cranberry	19
Ribes spp.	Currant	5
Rosa acicularis	Prickly rose	20
Calamagrostis canadensis	Bluejoint	18
Dryopteris dilatata	Spinulose shield-fern	7
Gymnocarpium sp.	Oak-fern	4
Echinopanax horridum	Devil's club	4
Cornus canadensis	Bunchberry	1
Mertensia paniculata	Tall bluebell	1
Rubus idaeus	Raspberry	3
Epilobium angustifolium	Fireweed	1
Epilobium latifolium	Dwarf fireweed	+
Salix novae-angliae	Tall blueberry willow	+
Rubus sp.	Bramble	+
Rubus arcticus	Nagoonberry	+
Trientalis europaea	Arctic starflower	+

[a] Birch-spruce stands were numbers 4, 11, and 29 (Figure 5). Number of transects sampled was 20.

Table 28. Characteristics of trees and tall shrubs in birch-spruce stands[a/] on downstream floodplain of Susitna River, summer 1981.

		Mean Height (m)	Mean dbh (cm)	Mean Age	Mean Crown Dominance	Number of Individuals Sampled
Alnus tenuifolia	Thinleaf alder	5.5	6.1	28	5	6
Alnus sinuata	Sitka alder	4.3	7.0	45	5	2
Betula papyrifera	Paper birch	15.5	29.2	72	2	30[b/]
Picea glauca	White spruce	16.2	27.1	91	2	32

a/ Birch spruce stands were numbers 4, 11, and 29 (Figure 5). Number of transects sampled was 20.

b/ Only 29 observations for age and crown dominance.

Table 29. Density (stems/ha) of woody species in birch-spruce stands[a/] on downstream floodplain, summer 1981.

				2 - 4 m Tall			
		< .4 m Tall	.4 - 2 m Tall	< 4 cm dbh	> 4 cm dbh	> 4 m Tall	Total
Alnus tenuifolia	Thinleaf alder		167	1033		408	1608
Alnus sinuata	Sitka alder		17	117		50	184
Betula papyrifera	Paper birch	50	350	400		227	1027
Picea glauca	White spruce		333	133	42	143	651
Echinopanax horridum	Devil's club		1183				1183
Rubus idaeus	Raspberry	3683	167				3850
Rosa acicularis	Prickly rose		16950				16950
Viburnum edule	Highbush cranberry	167	17050				17217
Salix novae-angliae	Tall blueberry willow		20C				200
Spiraea beauverdiana	Beauverd spiraea		100				100
Ribes sp.	Currant	10367					10367
Actaea rubra	Baneberry	83					83
Salix sp.	Willow	467					467
Total		14817	36517	1683	42	828	53887

[a/] Birch-spruce stands were numbers 4, 11, and 29 (Figure 5). Number of transects sampled was 20. Browsable stems were those taller than 0.4 m but less than 4 cm dbh.

Table 30. Characteristics of woody species in birch-spruce stands[a/] on downstream floodplain of Susitna River, summer 1981.

		Mean Height (cm)	Mean Length (cm)	Mean Width (cm)	Mean Age	Mean Crown Dominance	Number of Individuals Sampled
Salix novae-angliae	Tall blueberry willow	112	34	28	6	6	3
Salix spp.	Willow	78	68	33	7	6	1
Alnus sinuata	Sitka alder	225	101	62	12	6	5
Alnus tenuifolia	Thinleaf alder	226	105	83	11	5	8
Betula papyrifera	Paper birch	116	66	48	6	6	9
Rosa acicularis	Prickly rose	81	49	37	2	6	37
Viburnum edule	Highbush cranberry	94	49	35	5	6	40
Rubus idaeus	Raspberry	57	51	24	1	7	16

a/ Birch-spruce stands were numbers 4, 11, and 29 (Figure 5). Number of transects sampled was 20.

Table 31
With-project morphological changes
(Bredthauer and Drage 1982)

The project morphological changes for specific river reaches are summarized below:

RM 149 to RM 144

- The channel is stable and little change in form is expected.
- Portage Creek fan will progress out into the Susitna until equilibrium with the regulated Susitna stage is established. Perching of the stream mouth is not expected.

RM 144 to RM 139

- Erosion of valley walls and terraces will decrease dramatically due to the armour layer.
- Reworking of alluvial deposits in the main channel will continue but at a reduced rate.
- Main channel form will progress slowly to a more uniform sinuous pattern.
- Subchannels may become inactive.
- Tributary at RM 144 could become perched. It may not be able to regrade its coarse bed sediments to meet the regulated Susitna water level.

RM 139 to RM 129.5

- Indian River will continue to extend its alluvial deposits into the Susitna. Indian River should easily grade its bed to meet the regulated Susitna Stage.
- Gold Creek gradient is presently very steep as it enters the Susitna. The cobble and boulder bed will resist regrading the bed to meet the regulated Susitna stage.
- Fourth of July Creek gradient is currently relatively flat and should easily adjust to the regulated Susitna stage.
- Erosion of valley walls, terrace deposits and alluvial banks will reduce dramatically due to the armour layer.

Table 31 (continued)

- Reworking of active gravel bed materials will continue at a reduced rate. Main channel form will slowly progress to a more uniform sinuous pattern.

- Several of the sloughs and subchannels could be blocked off from the Susitna main channel at the regulated stage. Where these channels rejoin the Susitna, gradual siltation and vegetation encroachment will occur.

RM 129.5 to RM 119

- Erosion of valley walls, terraces and alluvial deposits will reduce dramatically.

- At RM 128 and 125.5, reworking of gravel bed material will continue, but at a reduced rate. Main channel form will become more uniform.

- Cobble berms at the side channels and sloughs will control and perhaps block main channel flow from entering them.

- The river should continue its preferred and stable route along the west valley wall.

RM 119 to RM 104

- No consequential changes in the channel morphology are expected.

RM 104 to RM 95

- Chulitna River will continue to expand and extend its alluvial deposits. Decreasing the summer flow magnitude in the Susitna River will allow the Chulitna to extend alluvial deposits to the east and south. This could induce erosion of the east bankline towards the railroad.

- Increased deposition at the confluence will cause backwater up the Susitna River. Lateral instability will continue after the project.

- The Talkeetna River will maintain the ability to create its channel into the Susitna system. No consequential interactions can be foreseen at this time.

RM 95 to RM 61

- Under post-project conditions, the bankfull flood (mean annual flood under pre-project conditions) could be expected to have a recurrence interval of once every five to ten years. This will tend to decrease the frequency of occurrence of both bed material movement and consequently of changes in braided channel shape, form and network.

Table 31 (continued)

- Over a long period, a trend towards relative stabilization of the floodplain features should occur. The main channel and major subchannels could progress to a more uniform meandering pattern. The active gravel floodplain may develop a vegetative cover and the minor subchannels become relatively inactive. It must be recognized that an extreme flood generated by either the Chulitna River, Talkeetna River, or both, could mask this process and delay observable changes for several years.

RM 61 to RM 42

- The Delta Island reach is a very complex and unstable channel network. There exists a very broad floodplain filled with varying channel types. Project induced changes in flow and sediment regime realized at this reach will be diluted by contribution from tributaries and by the Susitna satisfying its sediment load by reworking the wide floodplain alluvial deposits. Basic changes in the overall channel network are not expected.

- Local changes could occur in the main channel lateral position but basic channel geometry should remain relatively similar. To quantity post project morphology changes with respect to the natural system would be extremely difficult, if not impossible.

RM 42 to RM 0

- Effects of the project on river morphology through this reach of river would be extremely difficult or impossible to quantify. The dilution effect of major and minor tributaries as well as the balancing of changes by the Susitna River system should mask any measurable changes that could occur as a result of the project for several decades.

FIGURES

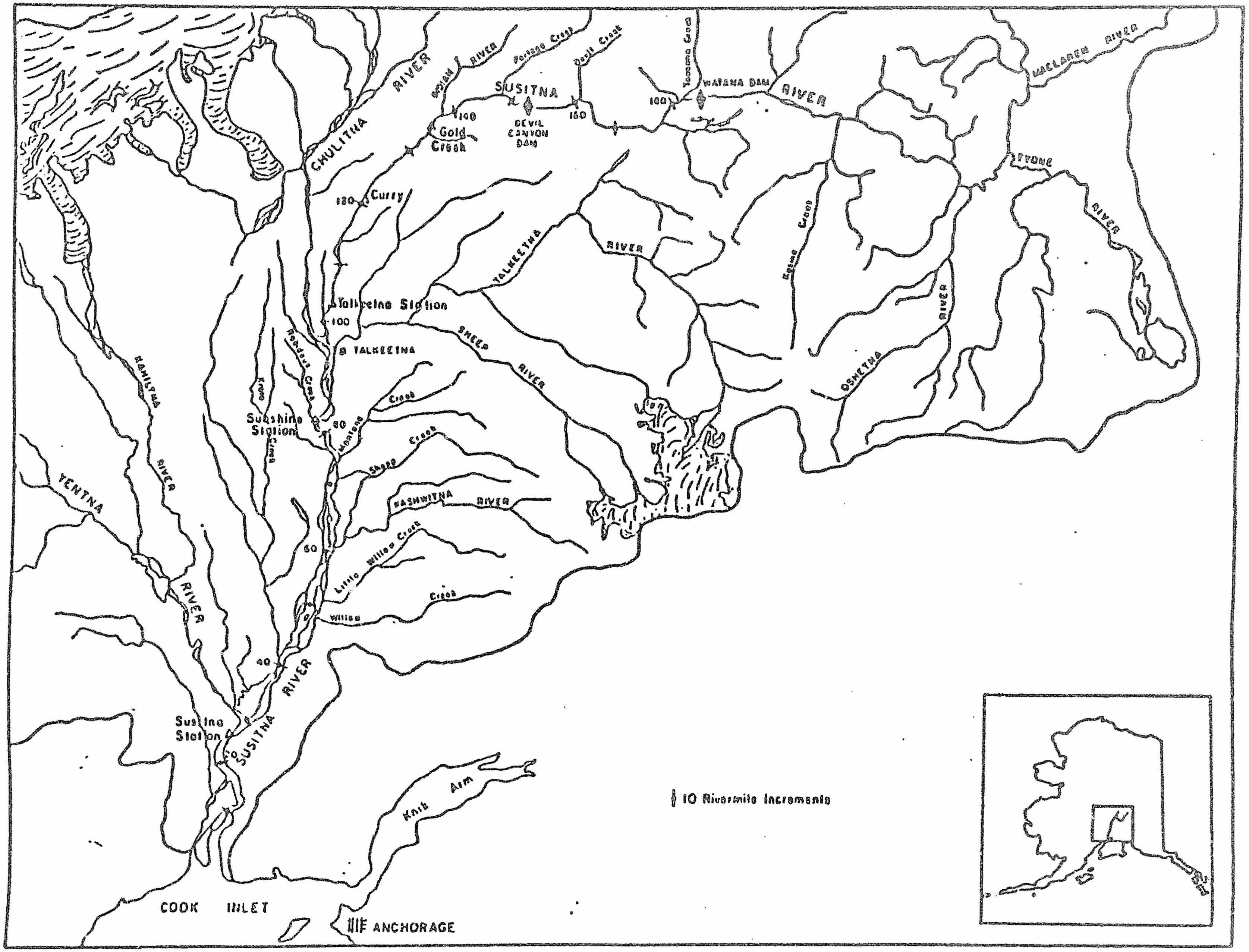


Figure 1. Map of the Susitna basin study region.

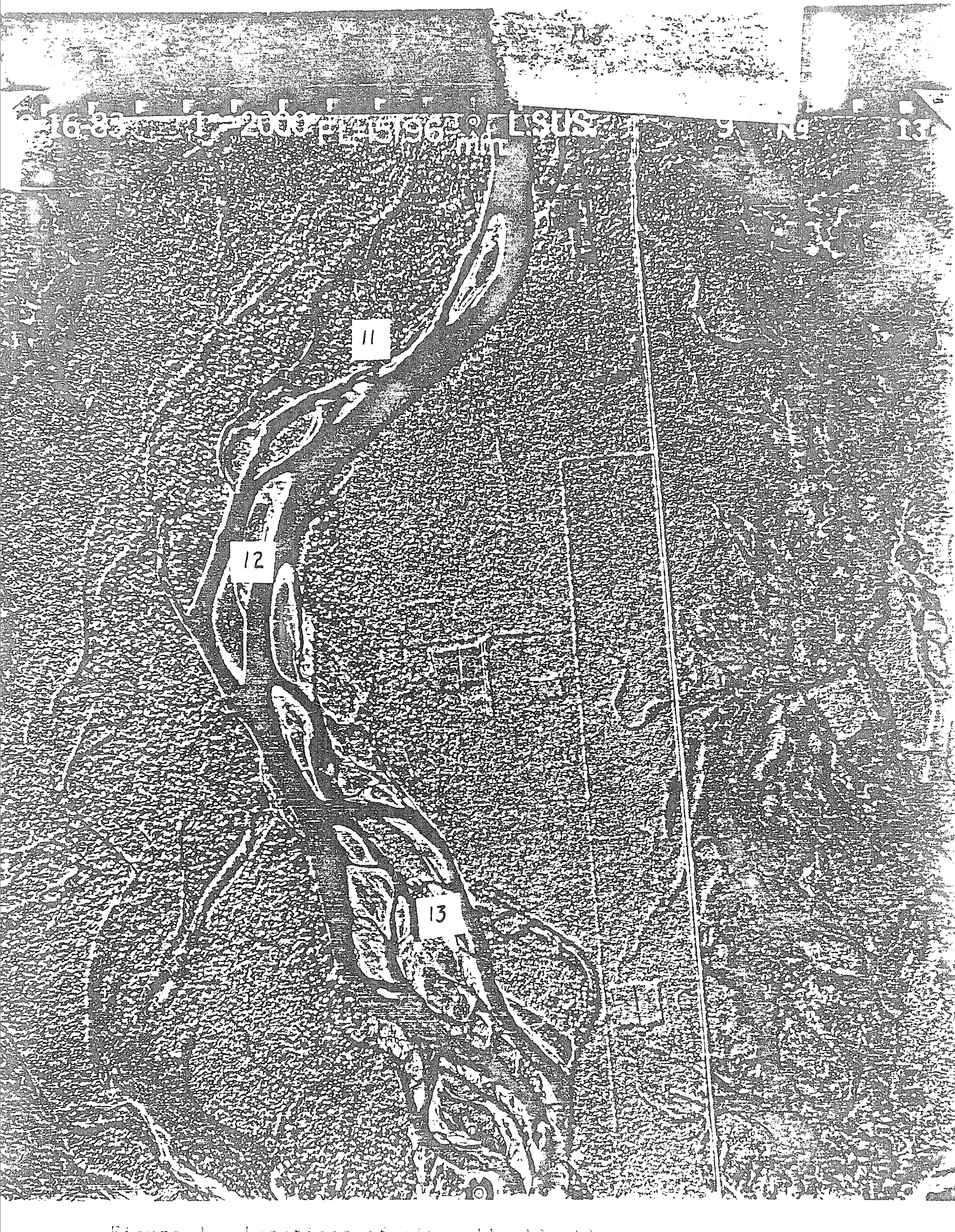


Figure 2. Locations of sites 11, 12, 13.

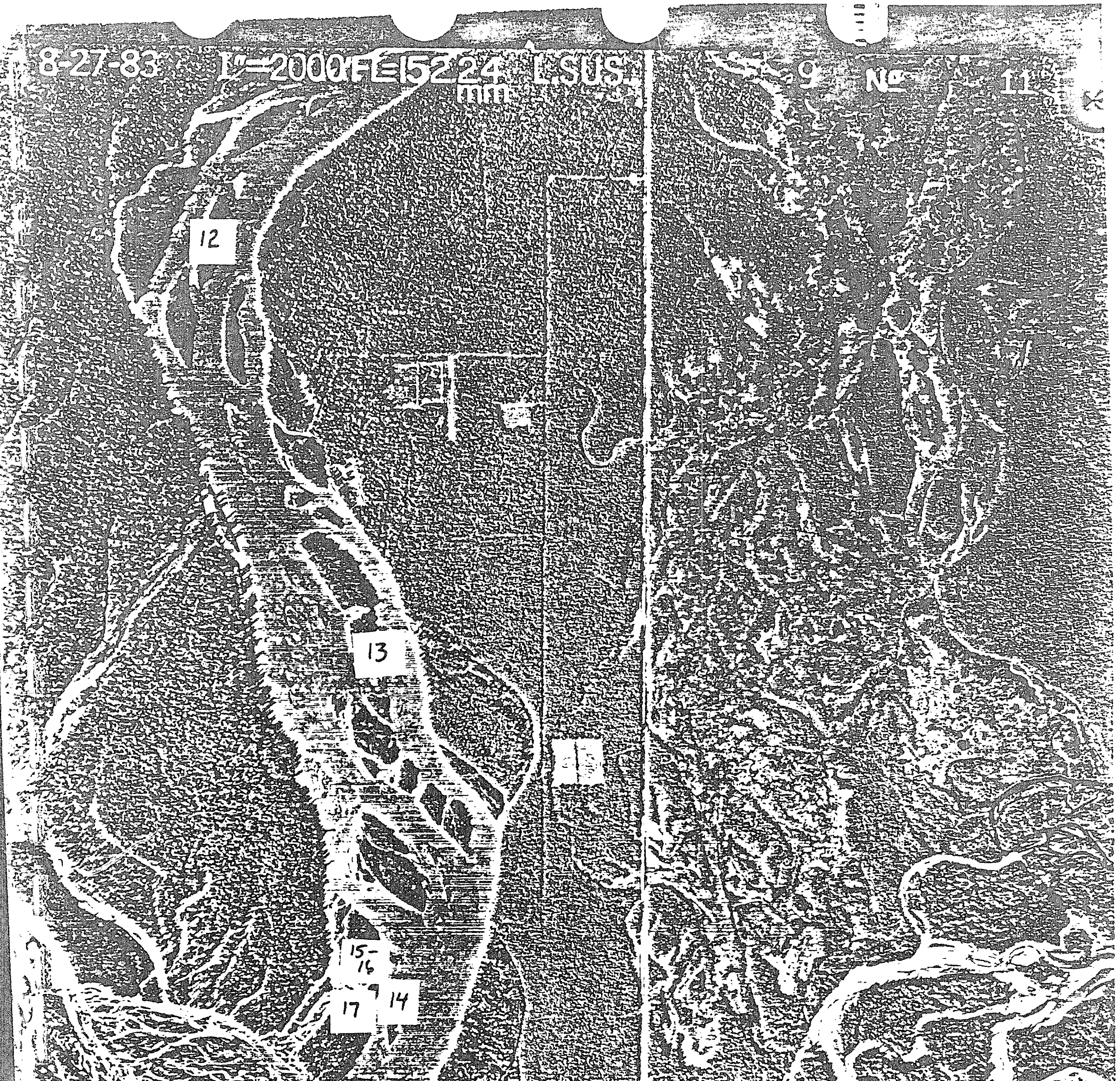


Figure 3. Locations of sites 12, 13, 14, 15, 16, 17.

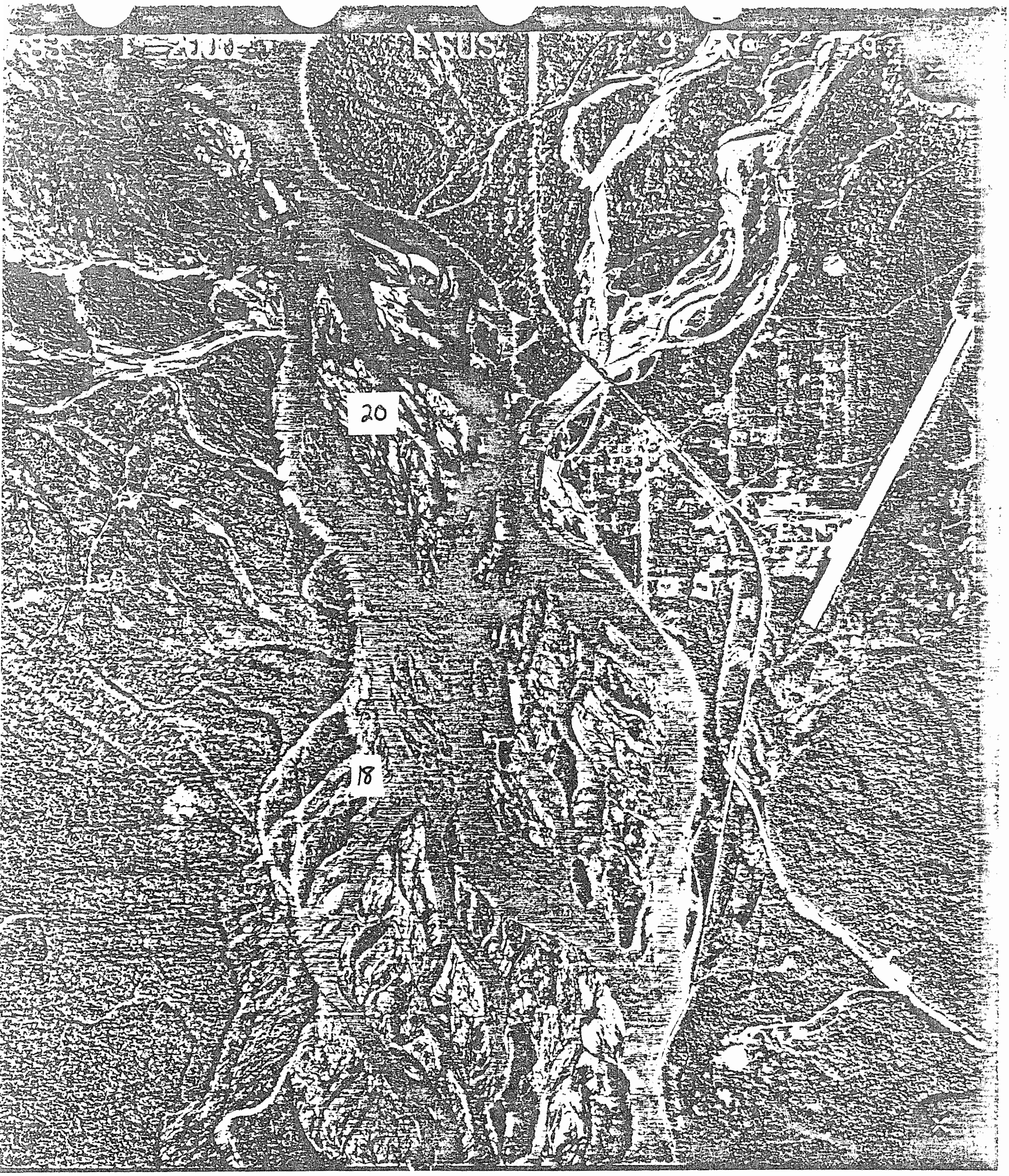


Figure 4. Locations of sites 18, 20.

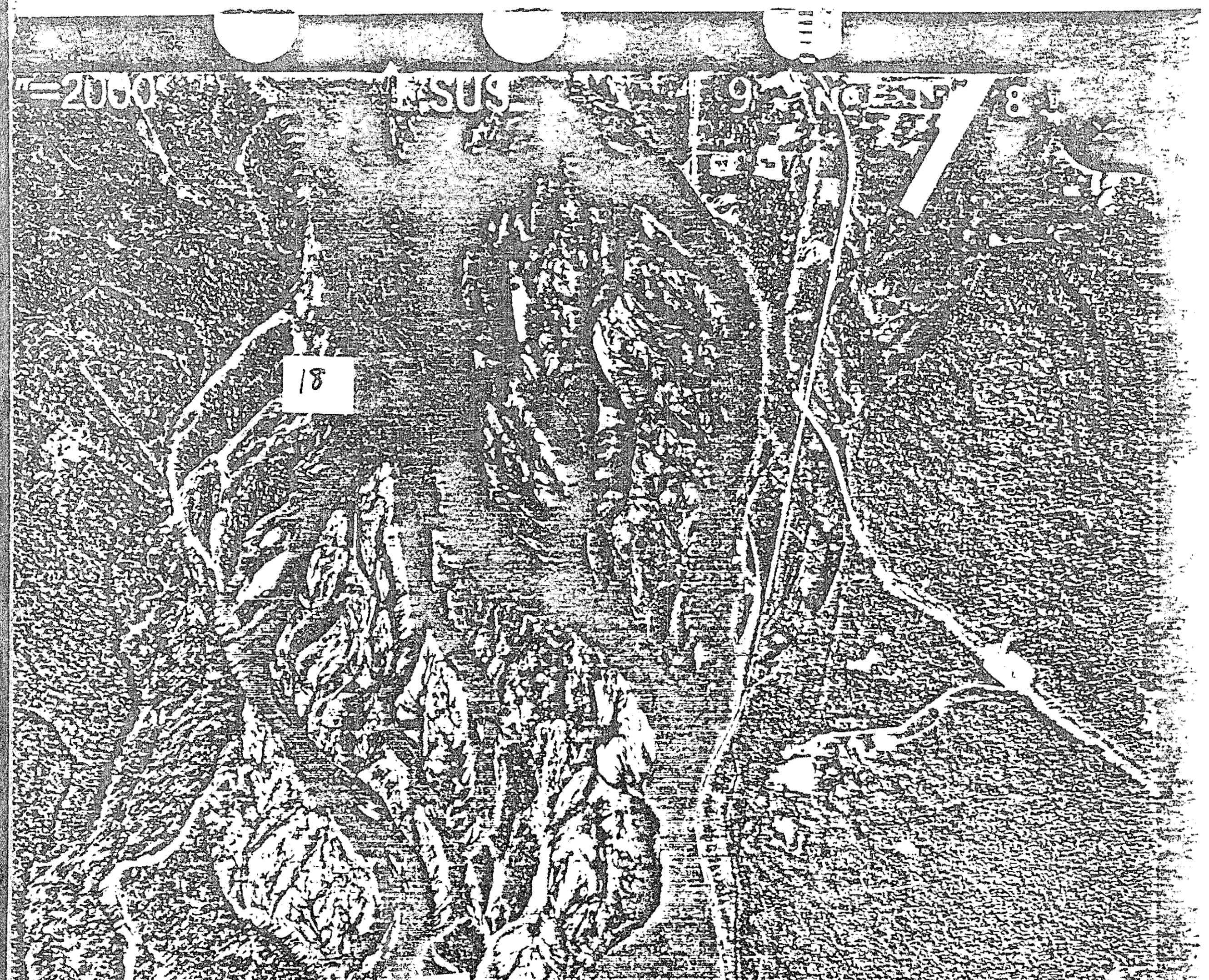


Figure 5. Locations of sites 18, 19.

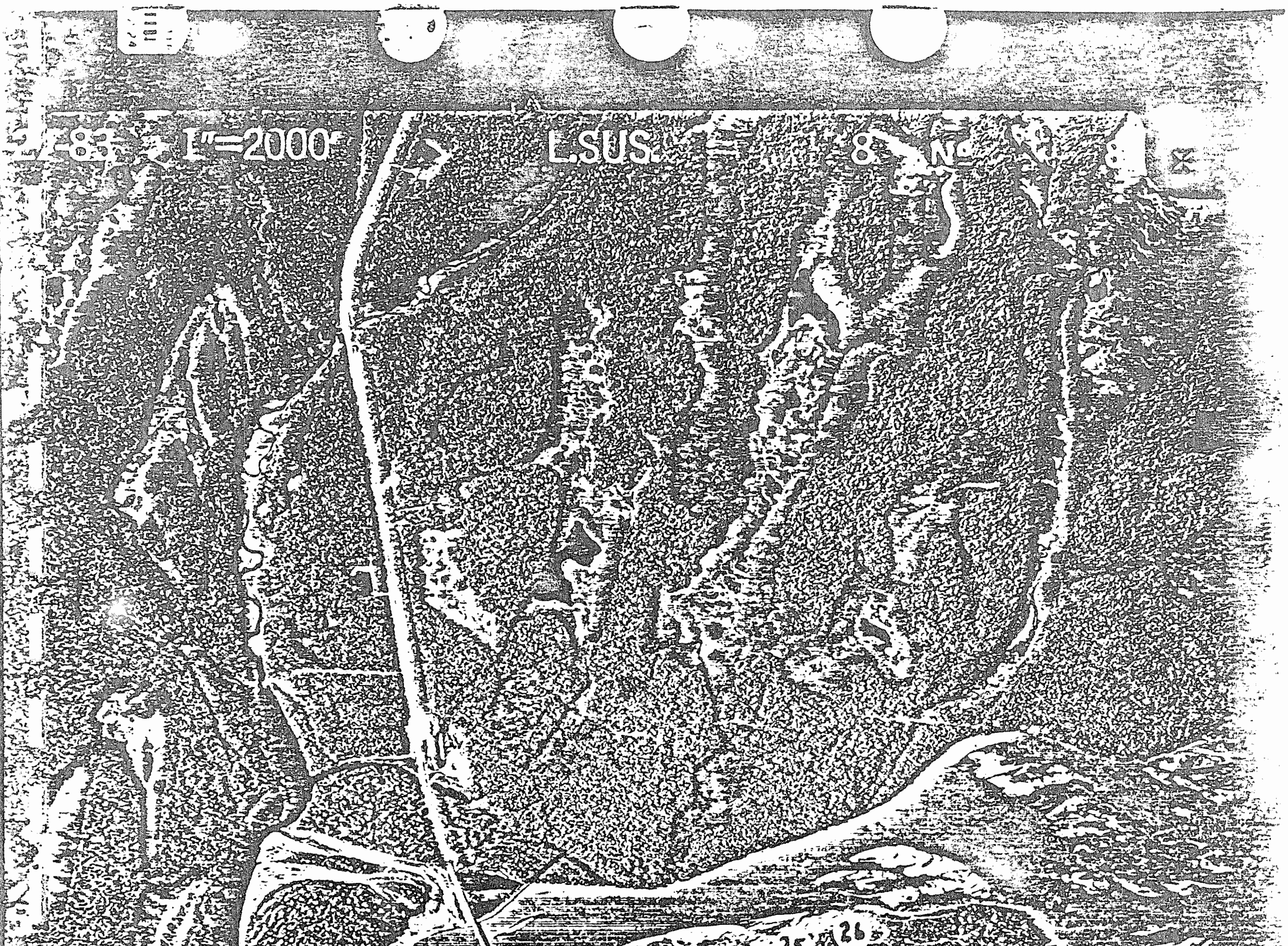


Figure 6. Locations of sites 25, 26.

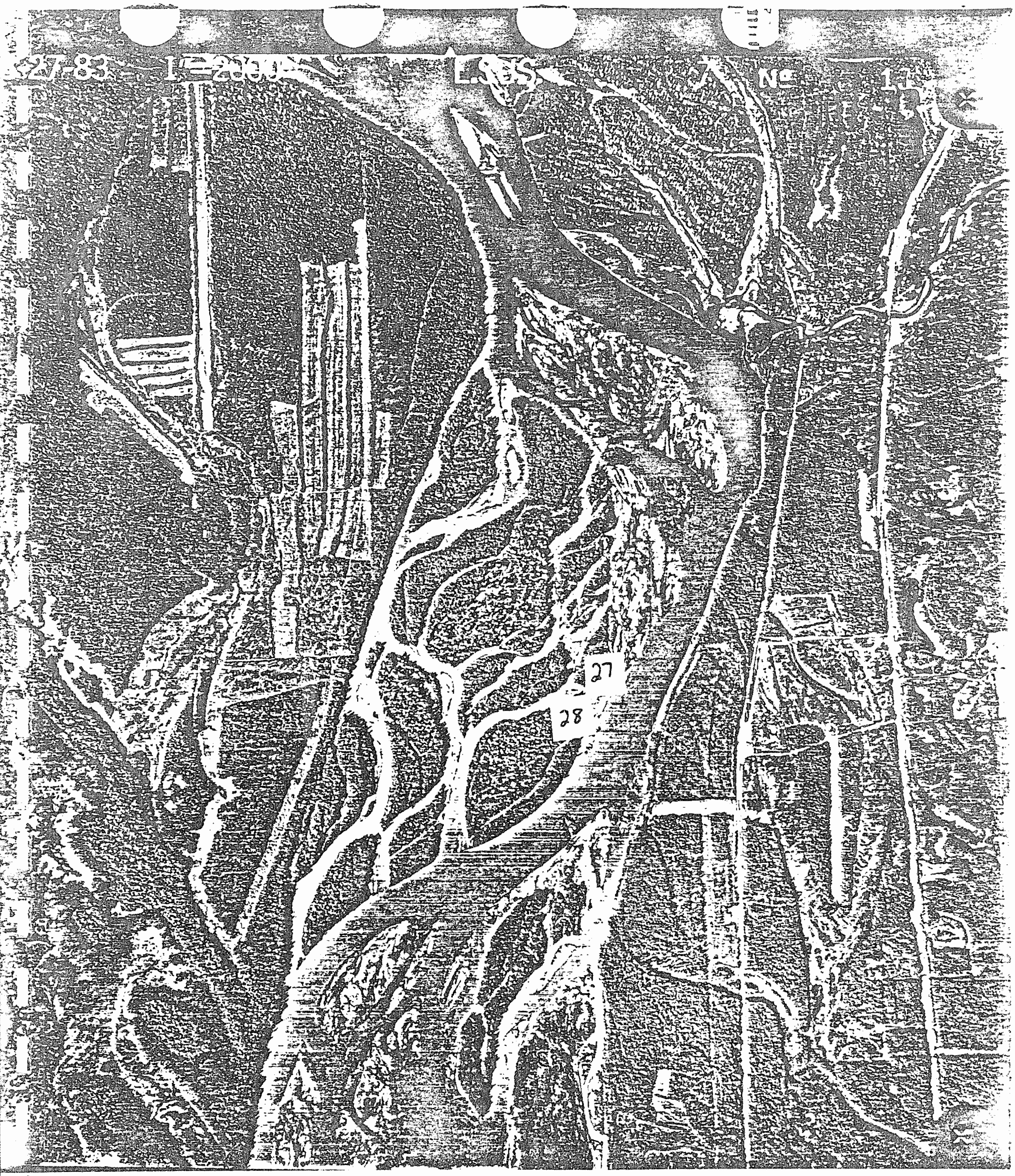


Figure 7. Locations of sites 27, 28.

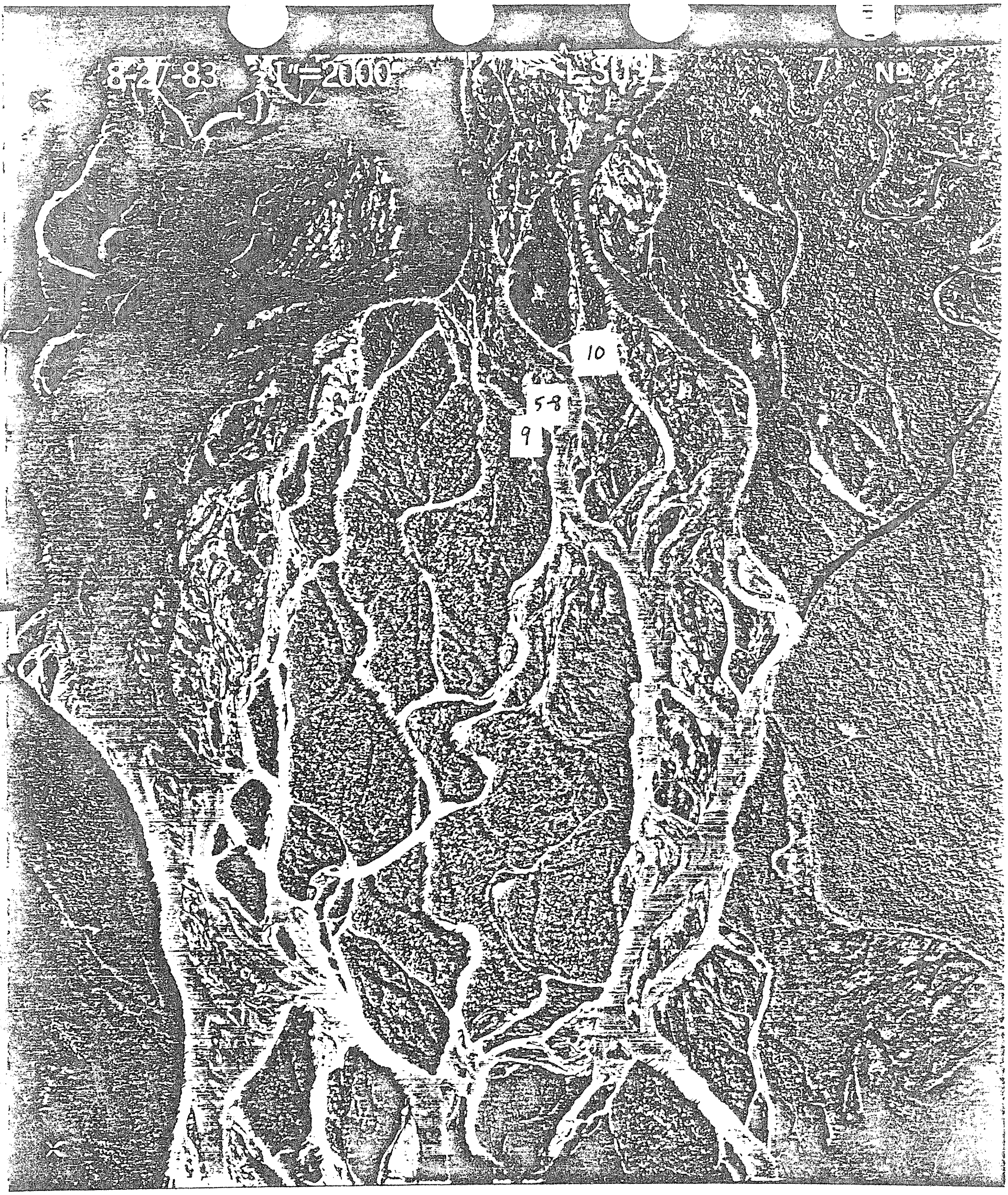


Figure 8. Locations of sites 4, 5, 6, 7, 8, 9, 10.

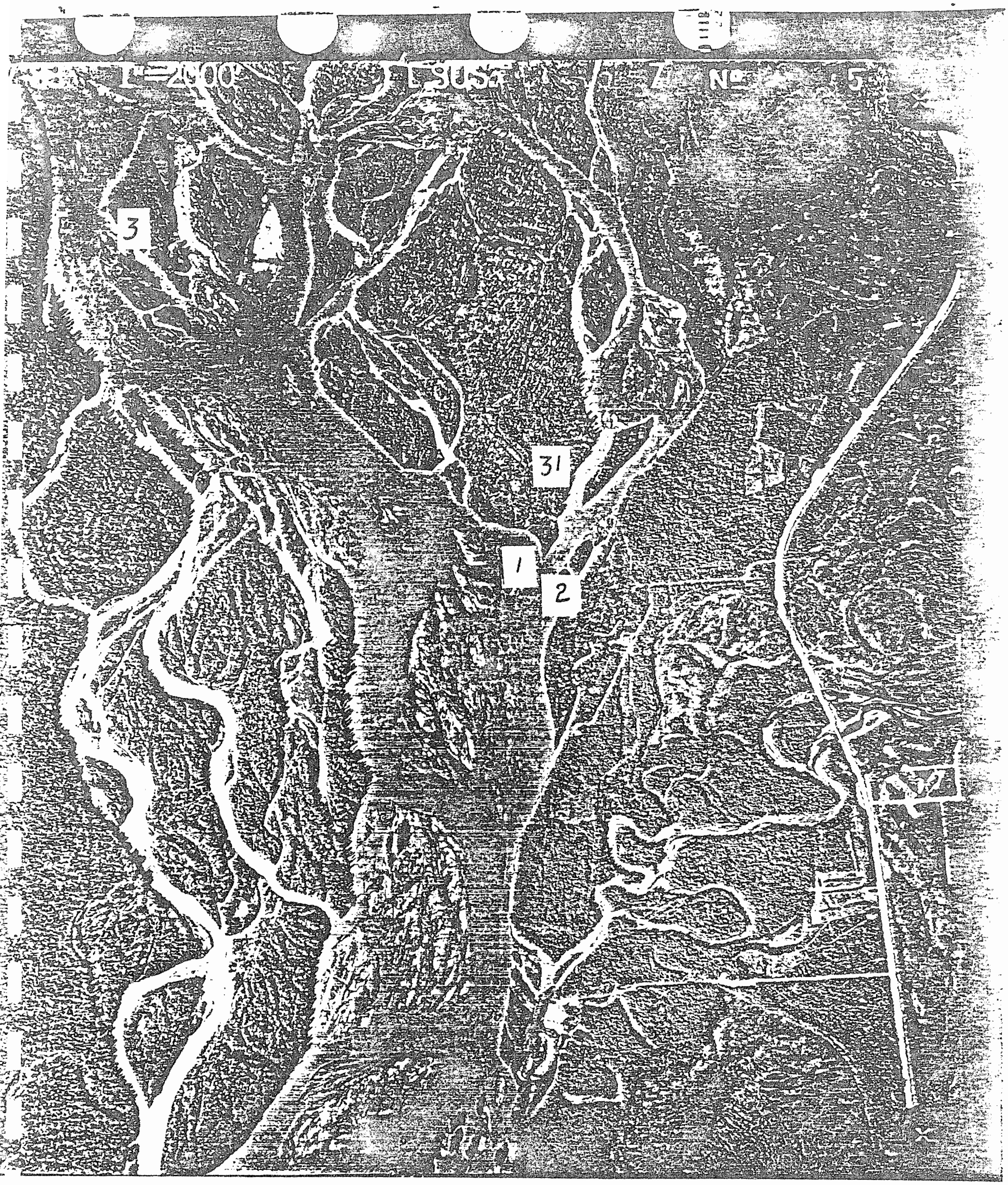


Figure 9. Locations of sites 1, 2, 3, 31.

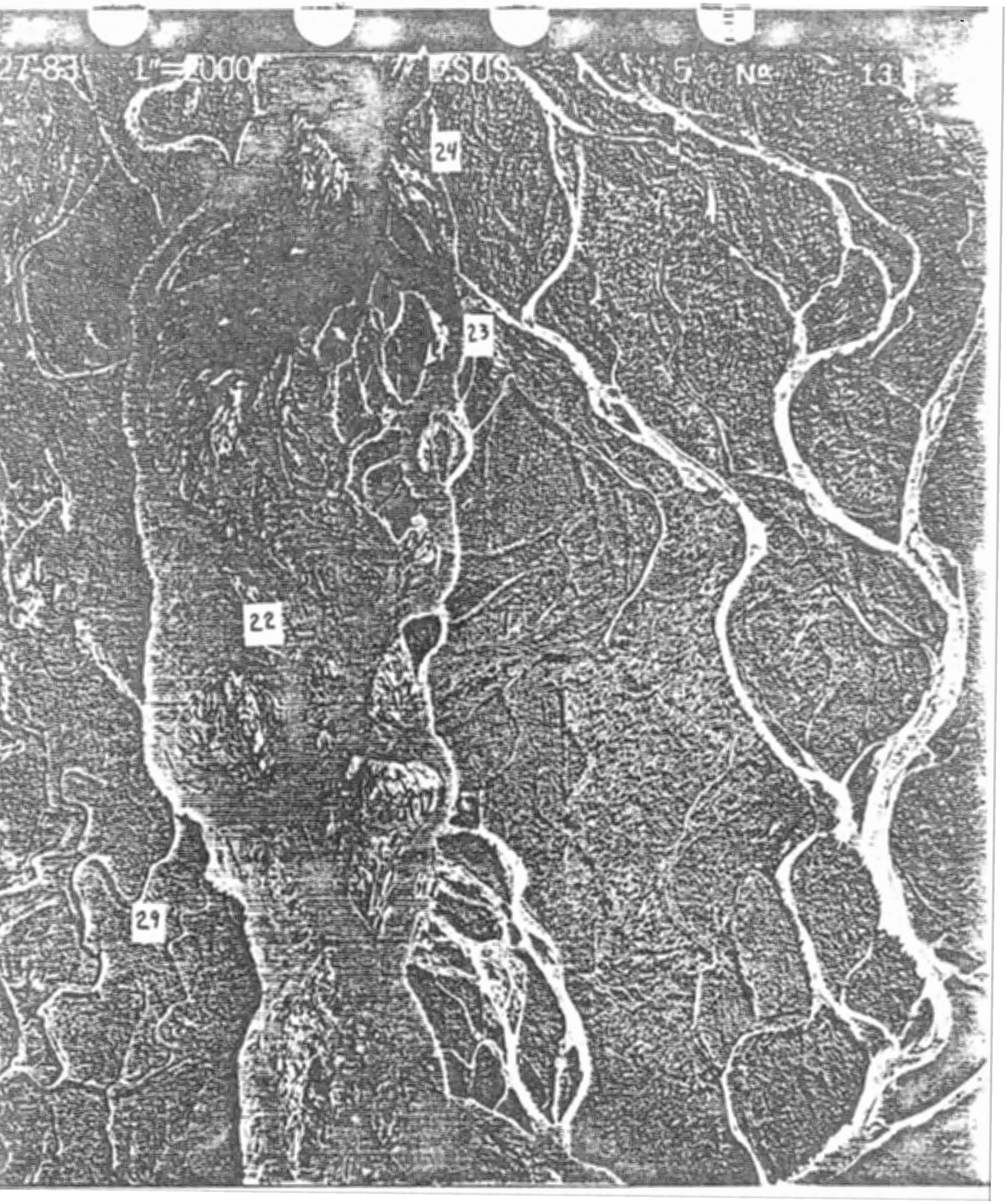


Figure 10. Locations of sites 22, 23, 24, 29.

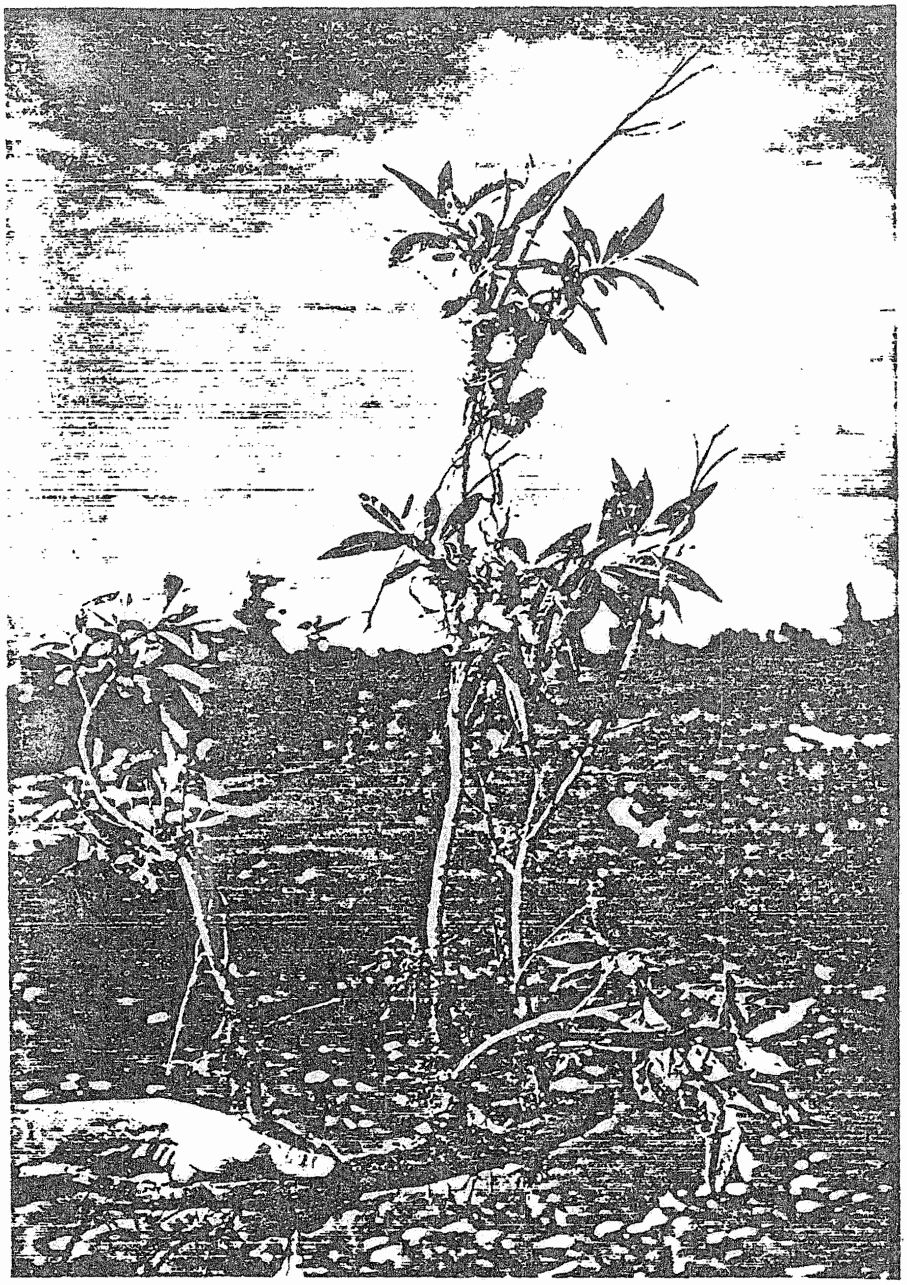


Figure 11. Feltleaf willow plant which has been buried and regrown.

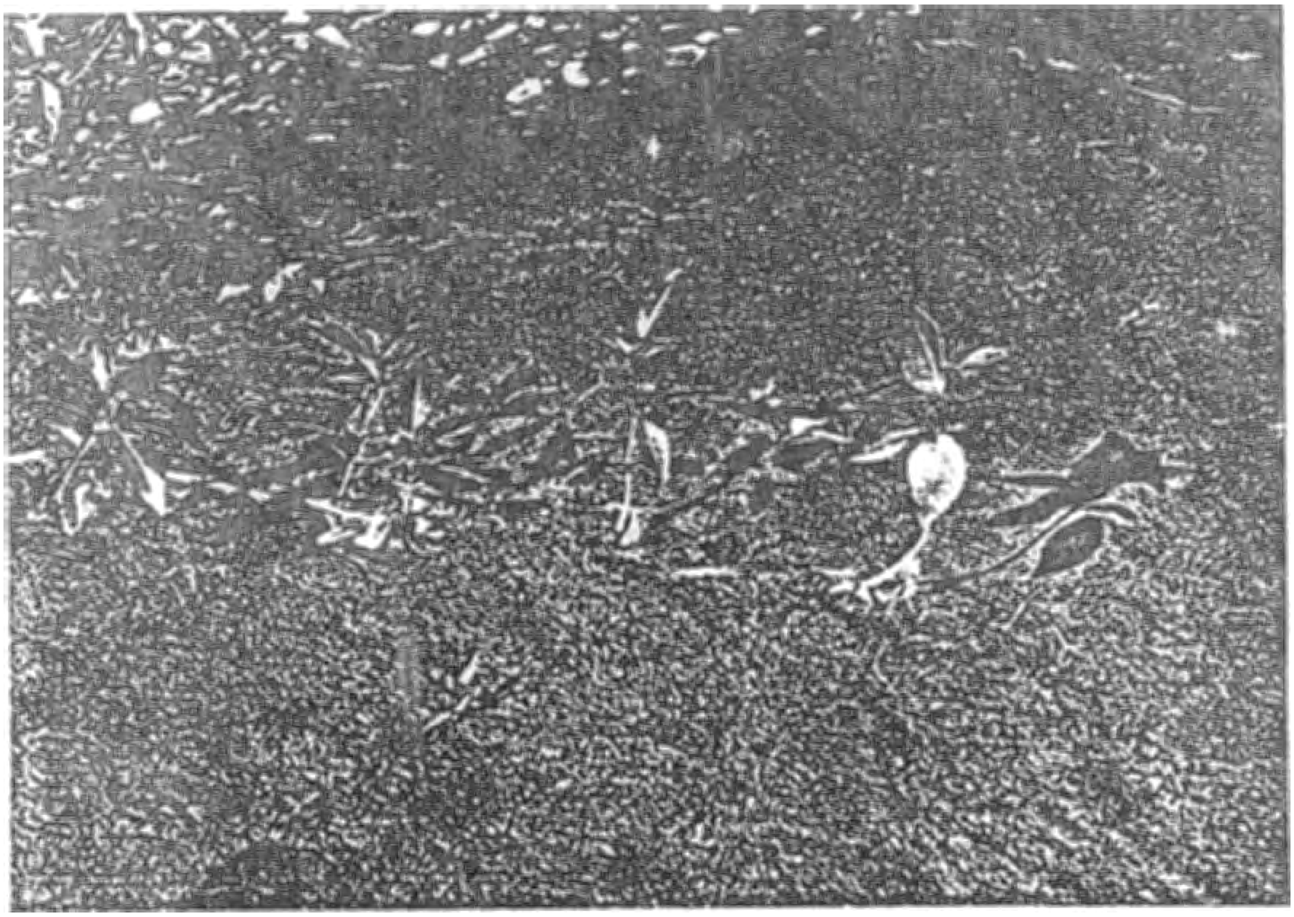


Figure 12. Balsam poplar plant which has been buried and regrown.

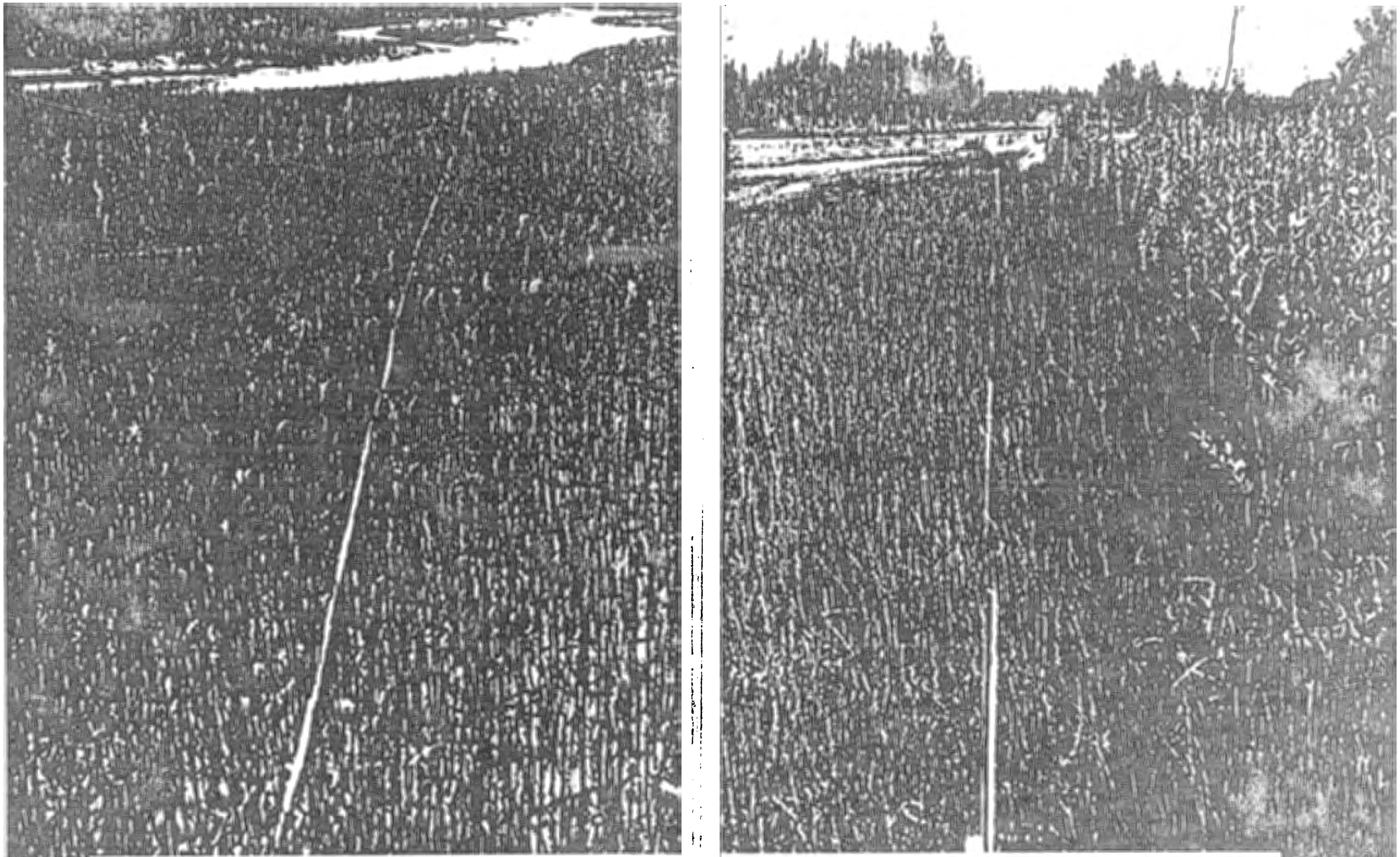
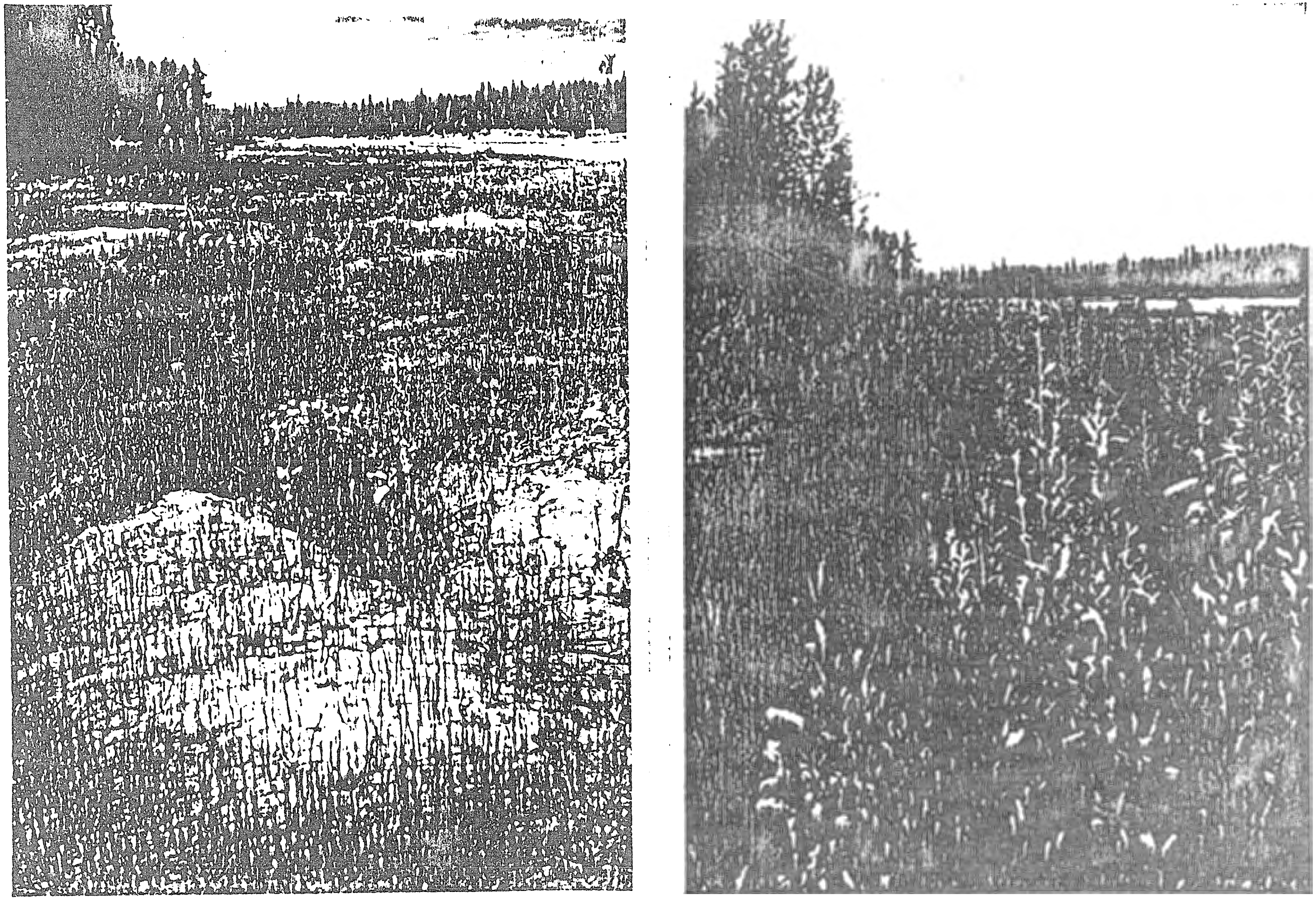


Figure 13. Horsetail site 8 in 1981 (left) and 1984 (right). Note the increased size of slough in background and reduced amount of land for horsetail site.

Figure 14. Horsetail willow site 13 in 1981 (left) and 1984 (right).



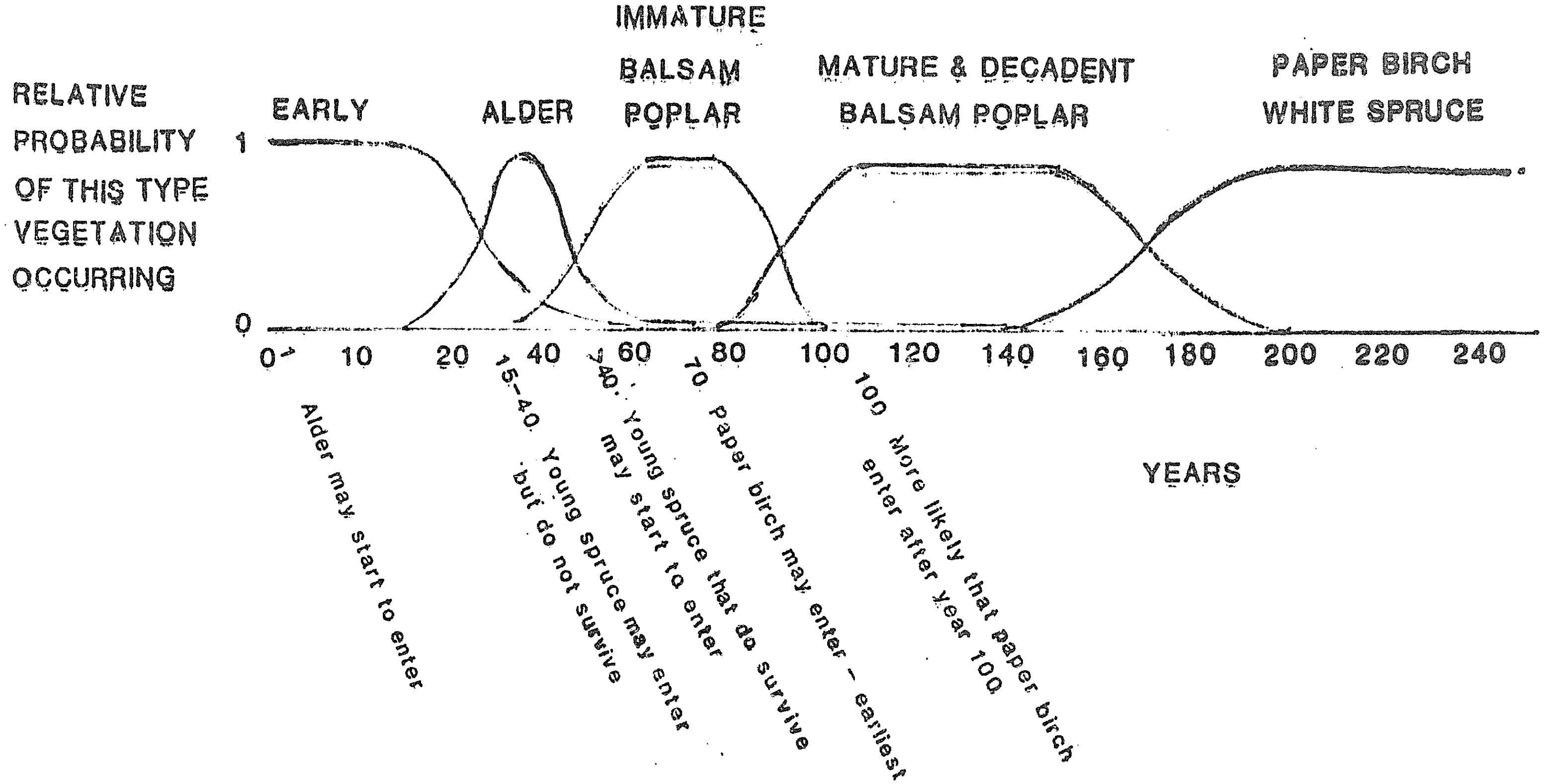


FIGURE 15. Time line indicating vegetation types and major events during succession along the Susitna River.

Figure 16. Alder and immature balsam poplar that have been bent during ice jam slooding, site 12.

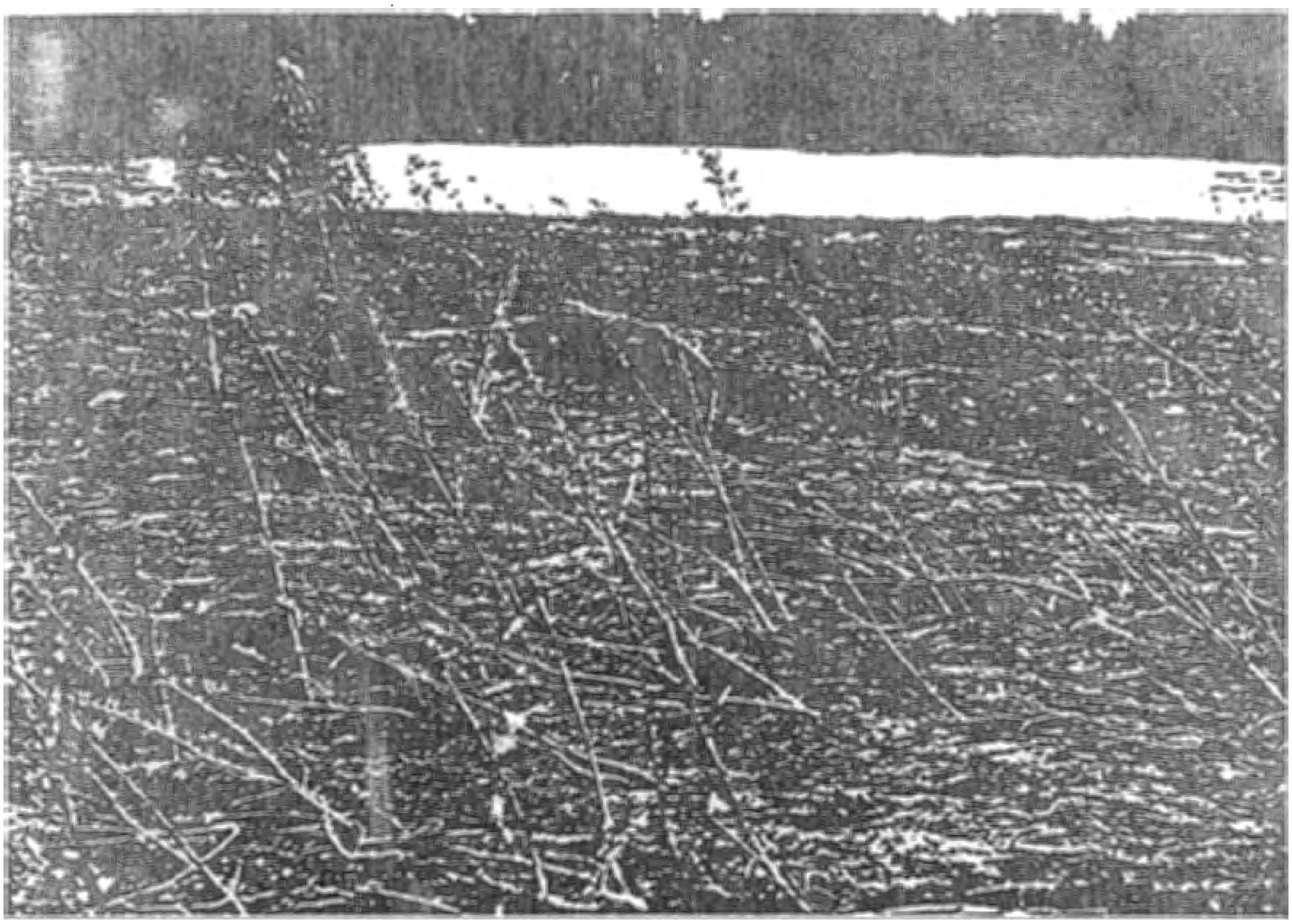


Figure 17. Young willows that have been scraped by ice, site 12, 1981.

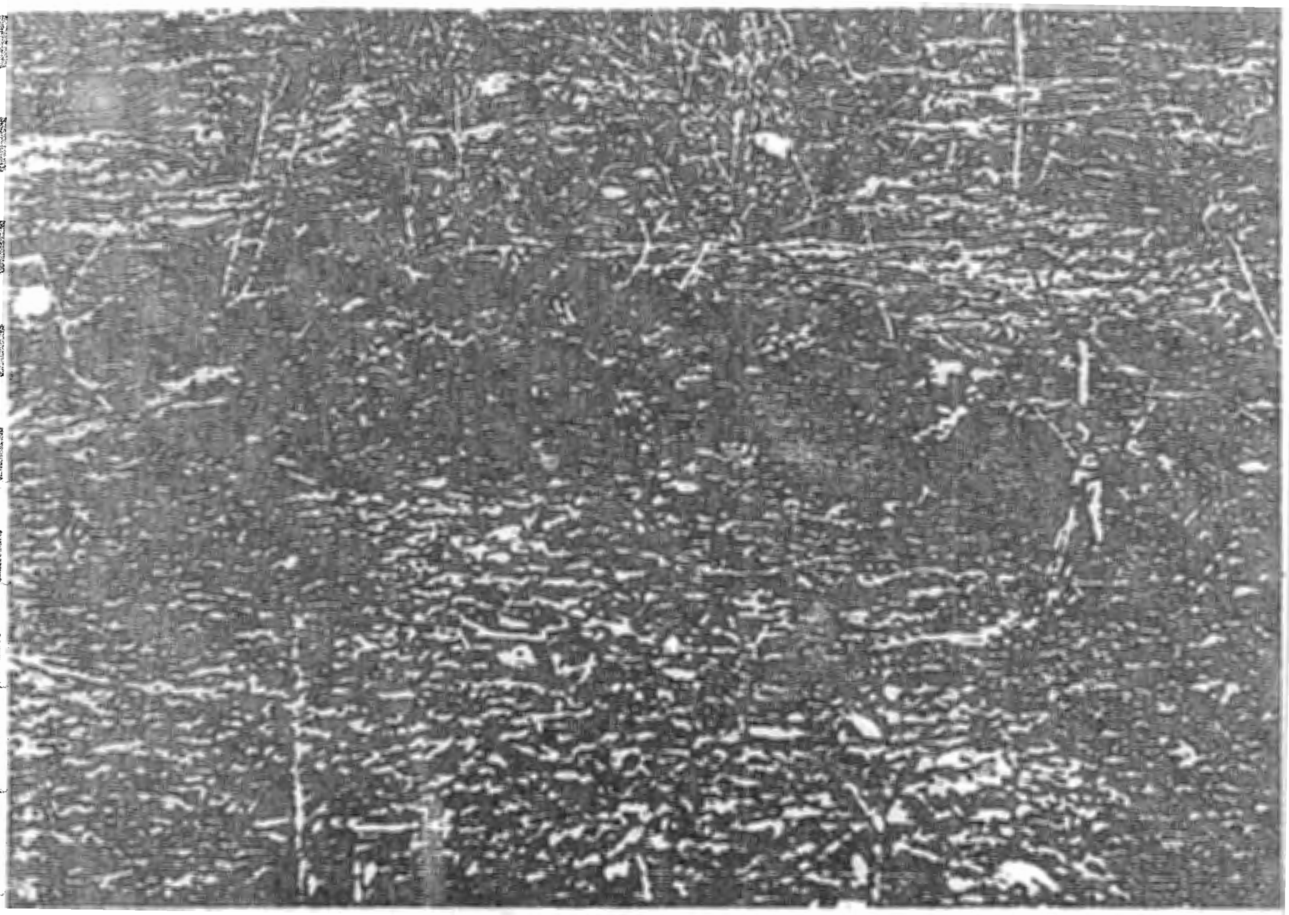


Figure 18. Young willows that have been pushed with the soil berm by ice, site 12, 1981.

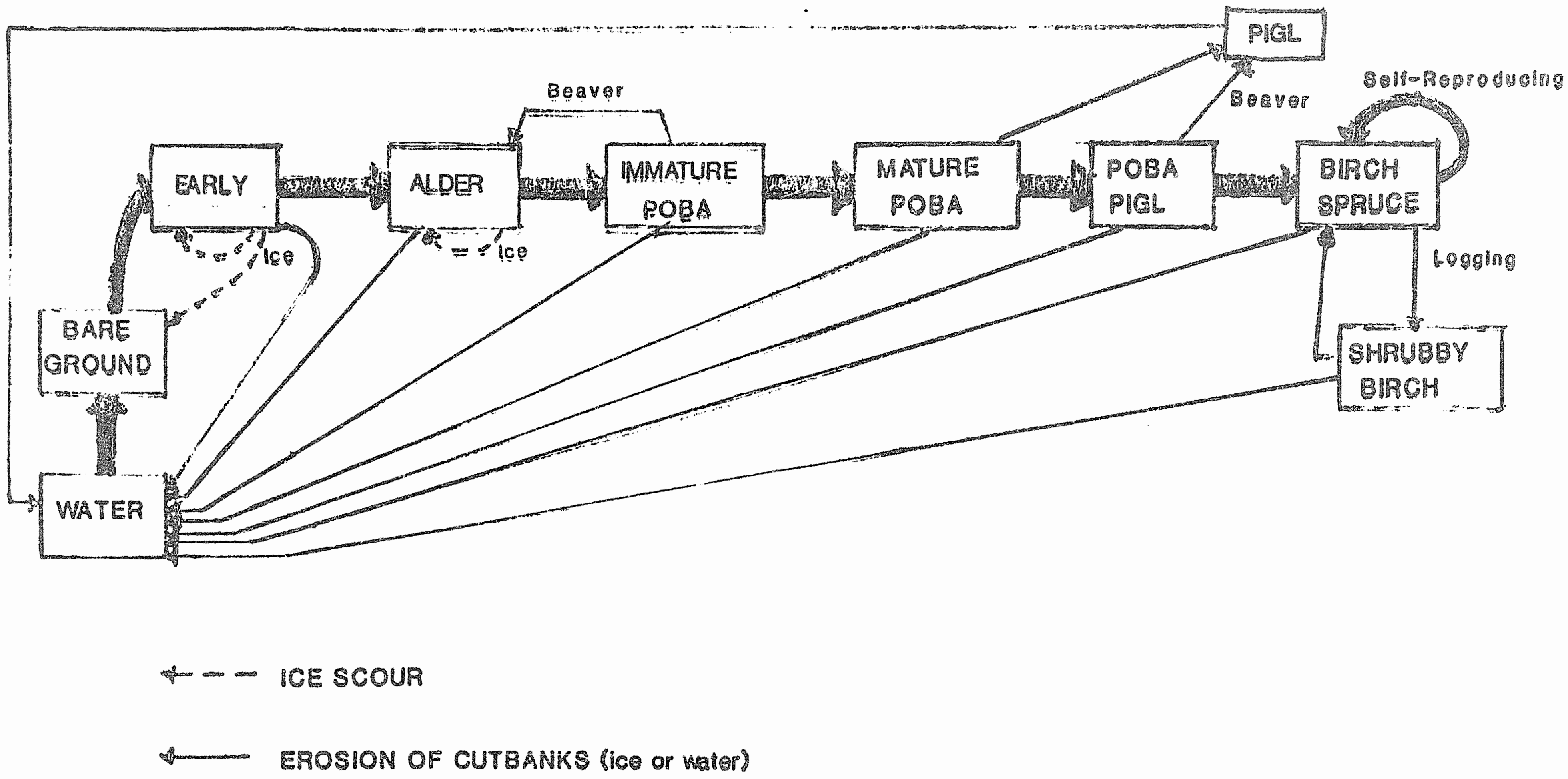


FIGURE 19. Diagram of conceptual model of vegetation succession along the SusitnaRiver.

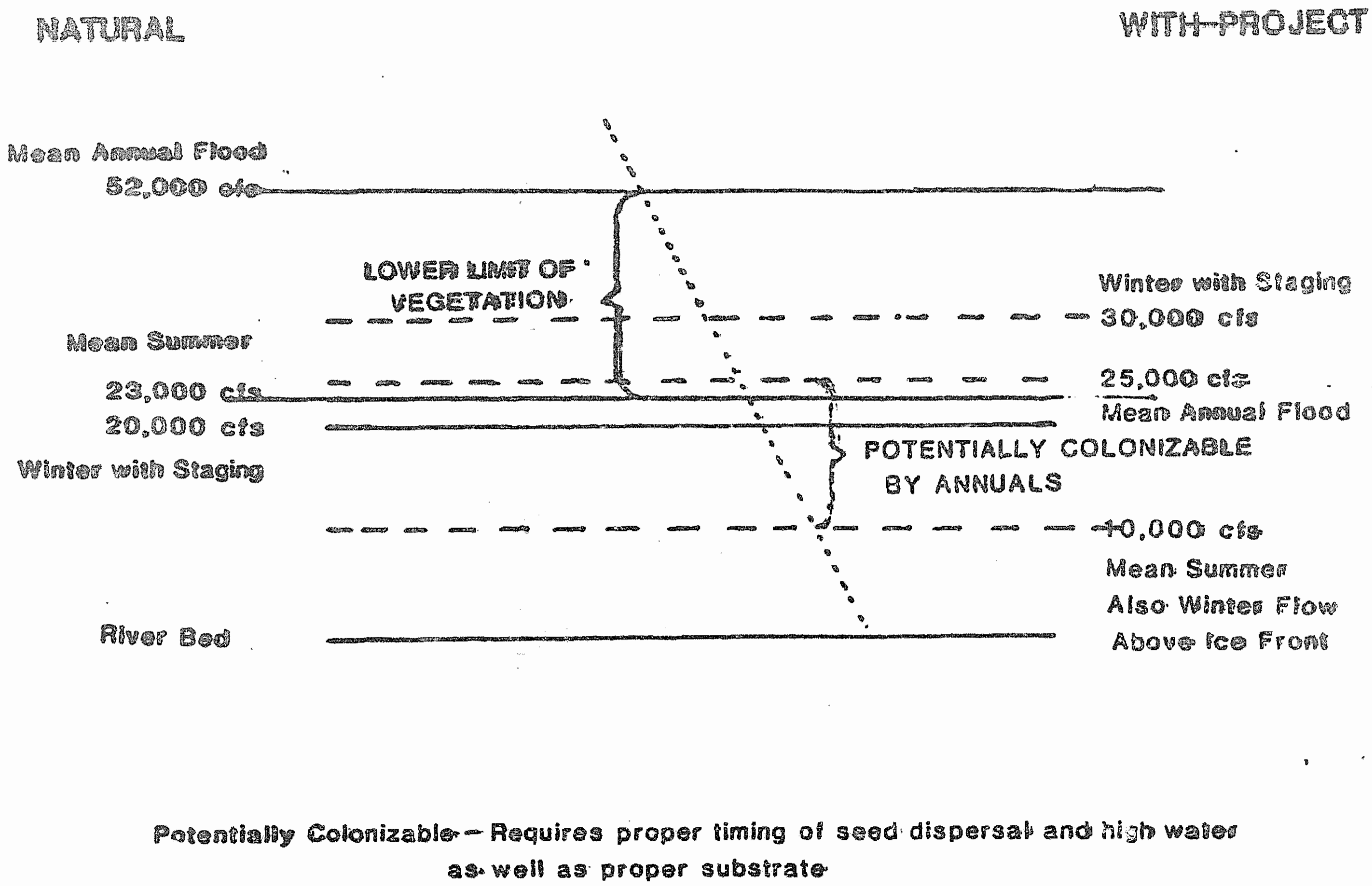


FIGURE 20. Natural and with-project water levels (open water flows) and their implications for vegetation establishment.