APPENDIX B

ECOLOGICAL DESCRIPTORS USED TO EVALUATE APPLICABILITY OF KRMB CREDITS

Introduction

To effectively offset yet unknown, future impacts within the proposed service area, the mitigation bank sites would best be representative of vegetative assemblages common in southwest Alaska and the Kuskokwim River watershed, as described below, and, therefore, have the potential to offset aquatic resources losses in similar vegetative assemblages. The proposed Kuskokwim River Mitigation Bank would maintain a credit ledger in three categories of wetlands corresponding to Level I of *The Alaska Vegetative Classification* developed by Viereck and others:[1] forest, scrub, and herbaceous. *The Alaska Vegetative Classification* is preferred for two reasons: 1) vegetative descriptions for Alaska have been developed and quantified by the U.S. Forest Service around this classification system, and 2) the system is hierarchal, allowing detailed descriptions of impact sites to be properly matched to the correct credit ledger category of the mitigation bank.

Also, in 2000 the U.S. Forest Service published its estimate of phytomass for southwest Alaska based on *The Alaska Vegetative Classification*.[2] The descriptions and estimates of acreage, used with knowledge of the potential mitigation bank sites, provide a quantitative guide to the selection of sites with vegetative assemblages representative of the watershed. The following descriptions from *The Alaska Vegetation Classification* are for the vegetation types most prevalent in the watershed and represented in the selected mitigation bank sites.

Forest

Forest is a Level I designation of *The Alaska Vegetative Classification*, which comprises needleleaf (conifer) forest, broadleaf forest, and mixed forest at Level II, and Level III

[1] Viereck, L.A.; Dyrness, C.T.; Batten, A.R.; Wenzlick, K.J. 1992. The Alaska vegetation classification. Gen. Tech. Rep. PNW-GTR-286. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 278 p.

[2] Mead, Bert R. 2000. Phytomass in southwest Alaska. Res,Pap. PNW-RP-523. Portland, OR: U. S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 164 p.

classifications based on crown coverage for each Level II classification. Needleleaf forest comprises 30% of the biomass distribution in southwest Alaska; broadleaf forest, 17%; mixed forest, 16%. Not surprisingly, tree-dominated plant communities comprise 63% of the biomass.[3] The most common forest communities occurring across the Kuskokwim River watershed are described below:

Black Spruce Forests

Black spruce (*Picea mariana*) is the most prevalent tree species in southwest Alaska, and is found in combination with co-dominants like white spruce (*Picea glauca*) and tamarack (*Larix laricina*) in varied habitats and tree densities throughout the interior forest of the Kuskokwim River watershed. In the "open canopy" classification, which implies crown canopy coverage of 25 to 60 percent, black spruce is dominant or co-dominant across 5.44 percent of all of southwest Alaska, but undoubtedly more prevalent in the interior forest regions. In the "woodland" classification, which implies crown canopy coverage of 10 to 25 percent, black spruce forests cover another 4.65 percent of southwest Alaska. In combination with paper birch (Betula papyrifera) in the open canopy mixed needleleaf-broadleaf forest, black spruce covers an additional 3.02 percent of southwest Alaska. (Again, there is greater prevalence for each in the interior forest.)

Black spruce open canopy and woodlands is the most prevalent community in the KRMB sites. The sparse canopy allows a rich assortment of herbs and shrubs in the groundcover, including:

Labrador tea
Bog blueberry
Resin birch
Alaskan spiraea
Reindeer lichen
Bog rosemary
Horsetail
Northern Red Currant

In its most prevalent community structure, open black spruce forest, trees are generally 9 to 30 feet tall growing at 480 to 1,500 stems per acre. Because of the prevalence of

[3] Ibid.

lightening-ignited fire in the Kuskokwim River watershed, stands are rarely older than 100 years, and most are much younger. Reproduction following fire is both by seeding (black spruce has semi-serotinous cones that release seeds for several years following a fire) and layering. With an open canopy, the shrub layer can be nearly continuous, and may include *Vaccinium uliginosum*, *V. vitis-idaea*, *Ledum groenlandicum*, *Rosa acicularis*, *Potentilla fructicosa*, *Empetrum nigrum*, and *L. decumbens*. Groundcover would commonly include *Calamagrostis* spp*., Equisetum sylvaticum*, *Rubus chamaemorus*, *Eriophorum vaginatum*, and *Carex bigelowii*. The ground may also be covered by feathermosses (commonly *Pleurozium schreberi* and *Hylocomium splendens*), *Polytrichum* spp., *Sphagnum* spp. and *Cladonia* spp. This community is considered climax on cold, poorly drained sites that burn frequently.

Closely related to open black spruce forests are open black spruce-white spruce forests and open black spruce-tamarack forests. Shrub and ground cover are similar to the open black spruce forest, but the tree canopy dominance is shared with white spruce and tamarack.

Woodland white spruce and black spruce communities, which can also have significant coverage by paper birch, white spruce and tamarack, are also common. Woodlands resemble open forest but have less than 25 percent crown coverage. Tree densities are low (180 to 1,200 per acre for stems greater than one inch diameter), growth is slow, and stands tend to be young. This community is found in several topographic positions, including floodplains, slopes, and ridges. Permafrost may be present or not, but soils are generally shallow to permafrost or bedrock. Fire is a dominant factor determining the shrub and groundcover composition, and the community is thought to be a fire climax. Succession after fire can give rise to a mosaic of groundcover and shrub communities, which may or not include *Sphagnum* spp. and *Cladonia* spp. Tall shrubs may include *Alnus crispa*, *Betula glandulosa*, and *Salix* spp., while the low shrubs are dominated by *Vaccinium uliginosum*, *V. vitis-idaea*, *Ledum groenlandicum*, *Rosa acicularis*, *Potentilla fructicosa*, *Empetrum nigrum*, and *L. decumbens*. Spruce regenerate by layering or seed following fire, but as with many fire communities the shrub and ground cover composition is influenced by the particular characteristics of the fire, as well as antecedent vegetation.

Natural fire is thought to be a critical factor maintaining the various forms of black spruce forests and its associated shrub, herbaceous, moss, and lichen communities. The latter are important food sources for moose and caribou, and episodic fire creates the rich mosaic of food sources through successional seres. Viereck[4] found that black spruce communities are the most frequently burned due to the abundance of ericaceous shrubs, the persistence of dead lower branches, which collect highly flammable epiphytic lichens, and the tendency of thick layers of mosses and lichens to dry out during periods without rainfall. He hypothesized that while black spruce would persist without fire in bogs and wetter sites, it

[4] Viereck, L.A. 1975.

would eventually be replaced by white spruce on drier sites. He also observed that while fire did not change the long-term vegetative composition of the spruce forest, it did give rise to an intermediate term shrub stage. This shrub stage is an important source of food for overwintering herbivores.

Mixed Needleleaf-Broadleaf Forests

White and black spruce mix with paper birch to form a mixed forests of varying stem densities, ranging from closed canopy (greater than 60 percent coverage) to open canopy (25 to 60 percent) to woodland (less than 25 percent). Spruce-birch stands tend to develop from pure or near pure stands of faster growing paper birch, which dominates in the early years. The birch fails to regenerate, become overly mature and dies by the time the stand reaches 120 years of age. White spruce tends to be the dominant spruce on well-drained to moderately well-drained sites, whereas black spruce predominates on the more poorly drained sites, slopes, and flood-plain terraces. A tall shrub layer comprising *Alnus crispa* and *Salix* spp. may be present. Low shrubs are nearly always present and may include *Vaccinium uliginosum*, *V. vitis-idaea*, *Ledum groenlandicum*, *Rosa acicularis,* and *Empetrum nigrum*. Feathermosses (commonly *Pleurozium schreberi* and *Hylocomium splendens*) are more likely in the groundcover than lichens. In more open canopy, the shrub layer may also include *Betula glandulosa*, *Spiraea beauverdiana*, and *L. decumbens*. These communities, because of the broadleaf component, tend to be more fire-resistant, as fire tends to stay on the ground when it reaches them. Thus, they form partial firebreaks, depending of course, on how dry conditions are when the fire approaches.[5]

Mixed forests on the KRMB sites are dominated by paper birch, black and white spruce, alders, and willows. The understory includes:

Horsetail
Club moss
Northern red currant
Alaskan spiraea
Prickly rose

[5] Ibid.

Mixed forests, while far from a dominant form, include mixtures with aspen (*Populus tremuloides*) and poplar (*Populus balsamifera*), as well as the more common mixture with paper birch.

White Spruce Forests

Similar to the previously discussed forest categories, white spruce can be dominant in forests of varying stem densities, ranging from closed canopy to woodland. As discussed above, white spruce tends to occur on more well-drained and less frequently burned sites. Open canopy and woodlands are the most prevalent in southwest Alaska, and the shrub community and groundcover is similar to that found in in the black spruce and mixed forests. Feather mosses are common understory, but may be replaced by *Sphagnum* spp. on sites with abundant precipitation and poor soil drainage.

Where they occur they may be climax communities, as white spruce does not store seed from year to year and, therefore, does not seed as prodigiously as black spruce following a fire.[6]

Shrub

Shrub is a Level I designation of *The Alaska Vegetative Classification*, which comprises tall shrub, low shrub, and dwarf scrub types at the Level II and Level III classifications based on coverage. Tall shrub comprises 20 percent of the non-forest shrub biomass distribution in southwest Alaska; low shrub, 7 percent; dwarf shrub 1 percent. With the forest and shrub communities considered together, these woody, persistent vegetative communities comprise 91 percent of the biomass. The most common shrub communities expected across the Kuskokwim Watershed are described below:

Tall Shrubs

Tall shrub types are generally a combination of alder (*Alnus crispa*), *Betula glandulosa* (or hybrids with *B. papyrifera*), and willow (*Salix* spp.). The most prevalent tall shrub types are closed canopy, probably as a result of prolific growth immediately following disturbance (e.g. fire, avalanche, sediment deposition) as a seral community. The low shrub and herb layer may be sparse under closed canopy and more prevalent under open canopy tall shrub.

Tall willow-dominated shrub may include *Salix alaxensis*, *S. arbusculoides*, *S. planifolia*, and *S. lanata* in closed canopy, with the addition of *S. glauca* and *S. bebbiana* in open canopy.

[6] Ibid.

Scattered alders may contribute to the canopy, and occasional balsam poplar and black cottonwood (*P. trichocarpa*) may overtop the willows. The understory is typically sparse in dense stands, where mosses such as *Hylocomium splendens* and *Drepanocladus uncinatus* may be abundant. Under more open canopies *Calamagrostis canadensis*, *Festuca altaica*, *Equisetum* spp., *Epilobium* spp., *Geranium erianthum*, and *Aconitum delphinifolium* may be found with other forbs. Lichens are generally rare, reflecting the early seral stage of the community.

Tall willow communities are common on floodplains, stream banks, lake margins, sheltered slopes, and other areas of disturbance. They are often seral communities following fire and being replaced by forests, yet in tundra regions willow stands slowly degenerate as the permafrost table rises and are eventually replaced by wet sedge meadow or tussock tundra types.

Like tall willow shrub, tall alder shrub is common on disturbed sites such as avalanche tracks, but also on steep alpine slopes and tundra uplands where it may be a topoedaphic climax. On disturbed sites, tall alder shrub is a seral community and will generally be replaced by forests. *Alnus crispa* commonly dominates on upland and well-drained sites, whereas *A. tenuifolia* is situated on wetter sites, such as shrub swamps. Under tall shrub closed canopy, understory plants may be sparse, but *Calamagrostis canadensis, Equisetum* spp., *Epilobium* spp., *Aconitum delphinifolium*, and feathermosses may be present. As with tall willow shrub, open canopy tall alder shrub will exhibit greater diversity, both in the overstory, where scattered balsam poplar and white spruce may occur, and in the groundcover, where low shrubs such as *Betula canadensis, Vaccinium uliginosum, and Ledum* spp. may be found. As with willow shrub, lichens are rare.

Alders are common tall shrub dominants on the Kuskokwim River Mitigation Bank sites.

As with many communities so closely related as willow and alder tall shrubs, there is a gradient between the pure types. Tall alder-willow shrub occurs on disturbed or naturally

unstable sites such as upland drainages on slopes, stream banks, and floodplains, and on narrow ecotones between forests and various treeless communities. Where conditions for forest development occur, the community is eventually replaced by trees.

Tall shrub swamps occur where there is standing water during much of the growing season. These swamps may comprise willow and *A. tenuifolia* as dominants. These communities are probably topoedaphic climaxes as long as hydrologic conditions causing standing water persist. Tall shrub communities are an important, but generally non-permanent, component of the boreal forest landscape.

Low and Dwarf Shrubs

Alders, willows, and shrub birches generally dominate the low shrub communities, although *Myrica gale*, *Potentilla fructicosa,* and ericaceous shrubs may also be dominant. The usual gradient occurs from closed to open, but in addition there is a classification gradient between low shrub and dwarf scrub with some plants like *Vaccinium uliginosum* and *Ledum* spp. generally assigned to the low shrub category and others like crowberry (*Empetrum nigrum*), *V. vitis-idaea*, *Arctostaphylos* spp., *Loiseleuria procumbens*, and *Diapensia lapponica* considered dwarf shrubs. In contrast to tall shrub, low shrub communities tend to be climax or, at least, subject to very slow change.

Low willow shrub communities are generally dominated by *S. glauca, S. planifolia*, and *S. lanata* in both open and closed canopy, with the addition of *Myrica gale* on wetter sites. Plants important in the understory of closed canopy low willow shrub communities include *Calamagrostis canadensis*, *Festuca rubra*, *Equisetum* spp., *Amemone* spp., *Sanguisorba stipulata*, and *Astragalus alpinus.* The understory of open of low willow shrub communities is often more ericaceous with *Arctostaphylos rubra* and *Vaccinium uliginosum*. Dwarf willows such as *Salix reticulate*, or subshrubs such as *Dryas* spp. may also be present. Low willow shrub communities generally occur in moist, protected gullies, drainages, stream banks, and scarps around lakes and ponds.

Open low mixed shrub-sedge tussock tundra and bogs are related communities, the former being extensive across Alaska tundra, covering 4.47 percent of southwest Alaska.[7] Shrub-sedge tussock tundra communities have at least 25 percent coverage by common shrubs such as *Betula glandulosa, B. nana, Ledum decumbens, Vaccinium vitis-idaea,* and *V. uliginosum,* and are dominated by tussock forming sedges, such as cottongrass (*Eriophorum vaginatum*) and *Carex bigelowii*. Crowberry is also common, as are mosses, which may include *Pleurozium schreberi*, *Hylocomium splendens*, *Aulacomnium* spp., and *Sphagnum* spp. Lichens such as *Cetraria cucullata, C. islandica, Cladonia* spp., *Cladonia rangiferina,* and

[7] Mead, Bert R. 2000.

Thamnolia subuliformis may also be common. The mixed shrub-sedge tussock community is associated with polygonal ground and is one of the most extensive tundra vegetation types in Alaska. It is generally considered to be a climax community, but if organic matter accumulates beyond the ability of the tussocks to keep their roots in unfrozen mineral soil, the tussocks eventually give way to wet shrub birch-ericaceous shrub or bogs. This is a long-term process and is impeded by fire removing the shrubs and mosses and releasing nutrients to the more fire-tolerant tussock plants.

Shrub-sedge tussock bogs are closely related to the shrub-sedge tussock tundra, and the differentiation between the two communities is primarily by location. The tundra communities are typically on poorly drained slopes, plateaus, and valleys, while the bogs are typically in floodplain depressions and poorly drained slopes. If this differentiation seems strained, it may be because the differentiation is not entirely on the expression of the community in terms of plants and their forms, but on the dynamics of drainage that has to be inferred.

Open low mesic birch-ericaceous shrub and bog communities are extensive in southwest Alaska, covering 6.09 percent of the area. They are similar to the mixed shrub-sedge tussock communities, but without the tussock-forming sedges as they occur successively on wetter sites. The mesic birch-ericaceous shrub occupies the point on the moisture continuum between shrub-sedge tussock tundra and shrub birch ericaceous bogs. Both shrub and bog communities support a similar complement of shrubs (*Betula glandulosa, B. nana, Ledum decumbens, Empetrum nigrum, Vaccinium vitis-idaea,* and *V. uliginosum*), but with different groundcover dominants. Common groundcover in the birch ericaceous shrub includes *Festuca altaica, Hierochloë alpina,* and *Carex bigelowii.* In the bogs *Rubus chamaemorus, Eriphorum angustifolium, Carex aquatilis, C. limosa, C. pauciflora, C. rotundata,* and *C. magellanica* may comprise the groundcover. Both communities support abundant mosses, including sphagnum and feathermosses.

Open low mesic birch-ericaceous shrub and bog communities are similar to the mixed shrub-sedge tussock communities, but without the tussock-forming sedges. The mesic birch-ericaceous shrub occupies the point on the moisture continuum between shrub-sedge tussock tundra and shrub birch ericaceous bogs.

A less common variant of shrub communities is that dominated by willow or alder, covering 1.51 percent of southwest Alaska and 1.13 percent, respectively.[8] *Salix glauca*, *S. planifolia,* and *S. lanata* are common in the willow communities, along with ericaceous shrubs such as *Arctostaphylos rubra* and *Vaccinium uliginosum.* In the alder communities, *Alnus crispa* is added to the willows mentioned above. Shrubby understory plants include *Spiraea beauverdiana, Betula glandulosa, B. nana, Empetrum nigrum, Vaccinium vitis-idaea,* and *Ledum decumbens.*

A less common variant of shrub communities is that dominated by willow or alder, covering 1.51 percent of southwest Alaska and 1.13 percent, respectively.[9] *Salix glauca*, *S.*

[8] Ibid.

[9] Ibid.

planifolia, and *S. lanata* are common in the willow communities, along with ericaceous shrubs such as *Arctostaphylos rubra* and *Vaccinium uliginosum.* In the alder communities, *Alnus crispa* is added to the willows mentioned above. Shrubby understory plants include *Spiraea beauverdiana, Betula glandulosa, B. nana, Empetrum nigrum, Vaccinium vitis-idaea,* and *Ledum decumbens.*

Shrub-sedge tussock tundra and bog communities support a similar complement of shrubs, but with different groundcover dominants.
These communities are a prominent feature of the Tundra Lake site. The community includes:

Bog blueberry
Cotton grass
Dwarf arctic birch
Cloudberry

Of the dwarf shrub types in southwest Alaska, the crowberry dwarf shrub tundra community is the most prevalent, covering 3.71 percent of the area. These crowberry-dominated communities may also have other dwarf shrubs, such as *Arctostaphylos alpina, Cassiope tetragona, Salix arctica, Dryas octopetala, Vaccinium vitis-idaea,* and *V. uliginosum*. Mosses and lichens, especially *Cladonia* spp., are common. Some stands of this community may resemble other ericaceous communities, but with more crowberry.

Herbaceous

Herbaceous is a Level I designation of *The Alaska Vegetative Classification*, which comprises non-woody species from terrestrial grasses to aquatic algae. At Level II there are four classes: graminoid herbaceous, covering about 7 percent of southwest Alaska; forb herbaceous and bryoid herbaceous, each covering about 2 percent; and aquatic herbaceous, covering less than 0.1 percent. While this coverage may seem small in comparison to the coverage of tree and shrub communities, it is important to remember that graminoids, forbs, and bryoids are important groundcover components of the forested

and shrub communities described above, which cover more than 74 percent of southwest Alaska, and they are only designated as herbaceous communities in the *absence* of 10 percent cover by trees or 25 percent cover by shrubs. The most common graminoid, forb, and bryoid communities expected across the Kuskokwim Watershed are described below:

Bluejoint Meadow

Bluejoint reedgrass (*Calamagrostis canadensis*) is the dominant in bluegrass meadows, often to the exclusion of most other grasses and herbs. Mosses are often absent or scarce, but feathermosses may be present when stands are not too dense. When the coverage of bluejoint reedgrass is complete, stands may reach three to six feet of height. While lichens and woody vegetation are excluded, this community often exists in a mosaic pattern with tall shrub (alder). Minor amounts of *Heracleum lanatum, Angelica lucida, Epilobium angustifolium, Trientalis europaea, Mertensia paniculata, Viburnum edule,* and *Equisetum arvense* occur in these meadows. Research in south-central Alaska indicated that mostly pure bluejoint meadows are likely preceded by bluejoint-herb meadows and without disturbance will slowly evolve through alder or willow shrub into a forest.[10]

Fresh Sedge Marsh and Related Meadows

Communities dominated by tall emergent sedges tend to be early colonizers of shallow freshwater areas around ponds, sloughs, and inland lakes. As plant detritus and other sediments accumulate and raise the soil level, they may be replaced by wet sedge meadows and later by sedge-shrub wet meadow. The early fresh sedge marsh may be dominated by *Scirpus validus* or *Eleocharis palustris*, but as the progression to wet meadow continues, *Carex aquatilis, C. lyngbyaei, C. rostrata, C. saxatilis, and C. sitchensis* become dominant.

Subarctic lowland sedge wet meadows are common throughout the subarctic as the successional replacement for fresh sedge marshes, occurring on floodplains and around the edges of lakes, ponds, sloughs, and upland depressions. As with the fresh sedge marsh, woody plants and lichens are scarce, but as the successional trend continues through the accumulation of organic matter and/or sediment, the soil level rises to the point that scrubs can survive. The resultant subarctic lowland sedge-scrub community often represents a broad ecotone between sedge wetlands and adjacent scrub types. Lichens are scarce, but mosses may be common. Important scrubs include *Myrica gale* and *Salix* spp., but while conspicuous, cover less than 25 percent.

[10] Mitchel, W.W and Evans, J., 1966. Composition of two disclimax bluejoint stands in south-central Alaska. Journal of Range Management. 19(2): 65-68

Wet meadows and fresh sedge marshes are common on floodplains and around the edges of lakes, ponds, and sloughs on the KRMB sites.

Wet meadows may also evolve into subarctic lowland sedge-bog meadows through the accumulation of peat, but sedge-bog meadows may also form around the edge of lakes or sloughs with saturated peaty soils forming quaking mats. Peat is usually more than one foot thick, comprised of sedge material, and supports communities dominated by the low peat-forming sedges, including *Eriophorum russeolum*, *Carex livida, C. limosa, C. puriflora, C. chordorrhiza,* and *C. magellanica.*

Mixed Subarctic Herbs and Fireweed

Found in small local patches along stream banks, mixed subarctic herb communities usually have complete ground cover, including common herbs such as *Campanula* spp., *Angelica* spp., *Lupinus* spp., *Artemisia* spp., *Lathyrus* spp., *Anemone* spp., *Delphinium* spp., and *Aconitum delphinifolium*. Woody plants are rare, but lichens may be present. A close variant is the fresh herb marsh dominated by emergent herbs in 6 to 40 inches of water. The characteristic dominant or co-dominant is *Equisetum fluviatile*, sometimes accompanied by *Menyanthes trifoliate* and *Potentilla palustris*. Where water depth is typically less than 6 inches, subarctic lowland herb wet meadows form. These are similar to wet meadows described above, but are dominated by *Equisetum arvense, E. variegatum, Caltha palustris,* and *Juncus arcticus*.

The fireweed (*Epilobium angustifolium*) communities are found on recent burns in interior Alaska, and without renewed disturbance will be either invaded by bluejoint grass to form a meadow, which may persist for many years before yielding to shrubs and trees, or may be replaced fairly quickly by trees and shrubs sprouting from roots and rhizomes following the disturbance.

Lichens

Lichens are common throughout most of the plant communities in interior Alaska, but become dominant in extreme environments where other plants cannot survive. Crustose lichens, especially xerophytic saxicolous (rock inhabiting) foliose lichens, such as *Umbilicaria* spp., *Xanthoria* spp., and *Parmelia saxatilis*, grow on windswept soilless sites such as rock outcrops. Foliose and fructiose lichens are dominant on exposed ridges and other severe environments that are slightly more amendable to plant growth than sites occupied by crustose lichens. These communities include species of *Cladonia, Cladina,* and *Stereocaulon.*