11620

Western Great Plains Floodplain Systems

BpS Model/Description Version: Aug. 2020

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| --- | --- | --- | --- |
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| None | None | None | None |

Vegetation Type

Mixed Upland and Wetland

Map Zones

38

Model Splits or Lumps

This Biophysical Setting (BpS) is lumped with 1469- Eastern Great Plains Floodplain Systems

Geographic Range

This includes the Great Plains river systems from eastern Montana west to the Rocky Mountain front. Such river systems include the Missouri, Musselshell, Yellowstone, Teton, Marias, and Sun rivers. The major tributaries to these river systems would be in this BpS. This includes the Cheyenne River in map zone (MZ) 31 into MZ29, Belle Fourche in Wyoming into South Dakota, and Little Missouri – North Dakota/South Dakota, Yellowstone River. In MZ30, it would be in section 331Md along the floodplain of the Little Missouri River. This would occur throughout MZ29 in Montana, including Yellowstone and its major tributaries in Big Horn, Tongue, Powder, and the Little Missouri. In MZ30 it would include the Yellowstone and Missouri rivers (ECOMAP sections 331E, 331M; Cleland et al. 2007).

In MZs 39 and 40, this system goes northwest from ECOMAP subsection 332Bb. It’s northwest of Yankton, South Dakota, which is a break in the Missouri River. The 11-mile-wide floodplain with eastern trees stops at Yankton, then going west, the floodplain is one mile wide and has only cottonwood as early tree species. In MZ38, this system occurs along major river systems, including the Platte River and Republican River. It is limited to Province 332.

It's difficult to determine geographically where the Western model ends and the Eastern model (BpS 1469) starts, but it probably starts/ends around Yankton, South Dakota or perhaps up to Fort Randall Dam might be a good dividing line for Eastern vs. Western on the Missouri.

See Adjacency/Identification (Adj/ID) Concerns box regarding smaller second and third order prairie streams and where they occur or what they're classified as. Also see Adj/ID box to describe how to distinguish this from Rocky Mountain riparian systems and the Eastern Floodplain Systems.

Biophysical Site Description

Alluvial surfaces, usually bare, within broad floodplains are present as low elevation shorelines and barforms. The slightly higher fluvial landform adjacent to the channel forms the first terrace for fluvial dependent species. Over time, laterally migrating point bars form bench platforms that may become late seral stage floodplain forests.

Great Plains riparian and floodplain systems will be at lower elevations in the plains matrix.

Dominant communities within this system range from floodplain forests to wet meadows to gravel/sand flats; however, they are linked by underlying soils and the flooding regime.

Vegetation Description

Dominant types in this system are cottonwood and willow. This consists of broadleaf deciduous forests dominated by cottonwood (primarily *Populus deltoides*), yellow willow, or peach leaf willow and sandbar willow. In the Milk River drainages, narrowleaf cottonwood (*Populus angustifolia*) is common (but rare or absent in MZ29 and 30). Narrowleaf cottonwood occurs in upper (intermountain valley) reaches of the Marias and Yellowstone rivers. Black cottonwood (*Populus trichocarpa*) is found along the Milk and Yellowstone, but only occasionally along the Marias (and not in MZs 29 and 30). Early seral stage phreatophytic vegetation becomes established on low elevation flood deposits; however, long-term survival is possible only on bare, moist sites on slightly higher elevation (1-3m above low water line, or slightly higher elevation possibly due to sedimentation over the original recruitment surface). Other species found in the floodplain riparian zone include sandbar willow, box elder, green ash typically associated with late seral stages. Box elder is present in the Dakotas.

*P. deltoides* and *Fraxinus pennsylvanica* are characteristic of Great Plains riparian forests. *Fraxinus* becomes a dominant in MZ30 riparian areas where it comes in after *P. deltoides*, grows much more slowly, but persists after *P. deltoides* because it can recruit into shaded, relatively undisturbed sites.

Green ash commonly forms a subcanopy in older stands and can eventually dominate if stands persist for more than 150-200yrs without major flood disturbance.

PODE is a pioneer species along Missouri River, in central North Dakota, in souteast South Dakota and near Omaha, Nebraska, and is replaced successionally by various combinations of *Fraxinus, Ulmus, Acer,* and *Celtis* (Hansen et al. 1984). Undergrowth is dominated by SYOC, RHAR (in the uppermost reaches but not in the plains), and other shrubs. Among the grasses, *Spartina pectinata, Elymus canadensis*, and *Muhlenbergia racemosa* are important.

In Theodore Roosevelt National Park in North Dakota, *Poa pratensis* is the most important grass, and *Melilotus officinalis* is the most important forb (Hansen et al. 1984).

Silver sage might be present in this system in the late successional stage. American elm is also a secondary successional species and codominant.

Understory species in these later seral stages may include dogwood, currants, snowberry, wild rose and chokecherry.

The 11-mile-wide floodplain with eastern trees stops at Yankton, South Dakota, then going west, the floodplain is one mile wide and has cottonwood and peachleaf willow as early tree species.

With the absence of fire and occasional overgrazing, silver sagebrush has locally invaded upland sites, which is how some range ecologists interpret it. It is unclear how extensive silver sagebrush was historically. The fact that sage grouse were historically collected all the way east to the Missouri River gives cause to wonder about the previous extent of sagebrush (Dave Ode, personal communication).

ARCA/PASM is fairly extensive along the floodplain of the Little Missouri River and along the first and possibly second terrace of some of the more major tributaries of the Little Missouri (Jack Butler, USFS, personal communication).

BpS Dominant and Indicator Species

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** |
| PODE3 | *Populus deltoides* | Eastern cottonwood |
| SALU2 | *Salix lutea* | Yellow willow |
| SAEX | *Salix exigua* | Narrowleaf willow |
| SAAM2 | *Salix amygdaloides* | Peachleaf willow |
| CORNU | *Cornus* | Dogwood |
| ROSA5 | *Rosa* | Rose |
| FRPE | *Fraxinus pennsylvanica* | Green ash |
| ARCA13 | *Artemisia cana* | Silver sagebrush |

Species names are from the NRCS PLANTS database. Check species codes at http://plants.usda.gov.

Disturbance Description

The development and maintenance of this system is dependent on fluvial geomorphic processes such as channel meandering/erosional processes of river flooding, sedimentation, erosion, channel avulsion and barform accretion driven by hydrologic variability. This variability incorporates the features of timing, duration, frequency, magnitude, and intensity of flooding. Regeneration of the dominant species (cottonwood and willow) is dependent on flooding and movement of river channels, which creates bare, moist soil needed for seedling establishment. Oxbow and slough development also influence the floodplain system and create variability in plant community composition. Upper terraces have infrequent flooding and scouring events, while the lower terraces nearest the river flood frequently.

Early seral stage development stands are produced on point bars via channel meandering, which occurs most often during moderately frequent high flows. They are also produced in other ways, i.e., there are two kinds of rivers, meandering as well as occurring on areas of sediment deposition. If a large flood and bare area created in the river, then the system is established. or via silt deposit that assists establishment (Scott et al. 1996). On braided rivers, e.g., the Platte, recruitment might occur most often during low flow periods when vegetation colonizes and stabilizes bars within the active channel (Johnson 1994).

Scouring caused by ice jams during the winter, channel meandering, oxbows and slough development greatly influence this system. Ice jams and ice scouring were not modeled.

Extreme drought can also kill cottonwood stands originally established under high-water table conditions; when drought is severe enough, available water in arid soil textures (coarse river deposits) is exhausted and shallow root systems are no longer able to reach fallen water table. Such drought was not modeled.

Changes in hydrology due to the activities of beaver are also an important ecological process in the Great Plains Floodplain, particularly on the tributaries (Little Missouri) to the Missouri River, as well as tributaries of the Yellowstone (Powder, Tongue, Big Horn). Beavers are present on the main stem Yellowstone River, but are not critically important because bank dens are frequently flooded and destroyed. Beaver impoundments kill trees (sometimes over large areas) and may create open water habitat, willow stands, or contribute to channel meandering. The effects of beaver ponds on forest dynamics in this system are also poorly understood at the landscape level, especially in the presettlement context. Note that beaver populations might have been maintained at artificially low levels on the Great Plains due to constant harvesting by humans. Beaver activity could have been a large influence in this system historically. It could have contributed to the system going from the mid seral stage to the silver sagebrush stage. However, this would happen if they were old stands on higher terraces close to the channel, but not if they were younger stands on lower, moister terraces. Cottonwoods on lower moister terraces would resprout and there would be a willow-cottonwood, beaver-induced disclimax. Beaver damage could be highly extensive in areas in this system (Lesica and Miles 2004; 1999). The effects of beaver activity on forest dynamics in this system are also not well understood at the landscape level, especially in the presettlement context.

Traveling ungulate herds and Native American activities locally impacted seral stage development. However, not enough is known about such disturbance to attempt modeling. Native Americans likely camped along rivers and used fire to attract game - low severity fires in early spring probably more frequent than 50-75yrs (Jack Butler, USFS, personal communication).

This seral community is most affected by fluvial geomorphic processes such as flooding, avulsion and deposition, and channel movement. The floodplain valley was modeled up to the last high terrace that rarely floods to reset to an early successional seral stage. The model does include shallow wetlands, sloughs or oxbows. Deep water habitat and the wetted width of the active river were not included in the model. Different flooding regimes were used in the model. The rivers flood to some extent almost every year. This annual, spring, snowmelt flooding is the primary driver of point bar formation. 50yr or 100yr floods can wipe out point bars, but they form lots of habitat for cottonwood and willow establishment through scouring and deposition. Minor, point-bar forming floods occur almost every year, while serious, scouring, high-terrace depositing events may be 20-50yrs. Flood frequency is also based on location on the floodplain, with higher terraces being subject to longer flood cycles.

Fire was a disturbance mechanism within portions of floodplain, however, the frequency and intensity is unknown. We can, however infer mixed severity fires in general, given the highly variable species and varying fuel amounts and spatial arrangements. The role of fire was less important, with relatively infrequent and patchy, low-to-mixed severity fires. A reviewer (Steve Barrett, personal correspondence) for Montana map zones commented that the overall Mean Fire Return Interval (MFRI) was probably approximately 50-75yrs given the presumably abundant ignition opportunities in the neighborhood, i.e., occasional fires spreading into this BpS from adjacent frequently burned grasslands. The overall MFRI was thus modeled as such. However, Butler commented that Native Americans likely camped along rivers and used fire to attract game - low severity fires in early spring probably more frequent than 50-75yrs (Jack Butler, USFS, personal communication). Upon review in MZs 39 and 40, it was stated that fire was probably not a very important feature on the floodplain forest (Dave Ode, personal communication). Another reviewer for MZs 31, 39 and 40 stated that these sites were 1) often somewhat protected from fire in three directions by being located within river bends, and 2) considered highly valuable by Native Americans, especially for protected winter occupation, complete with firewood, and even some supplemental forage for a few select horses (ca. 1700ad and after) in the form of young cottonwood bark. It would have been a fairly trivial exercise for Native Americans to protect these sites from wildfire/upland fires by essentially blacklining grass/tree boundary under appropriate weather conditions. Some such protection probably was provided, given that even light surface fires are extremely destructive to mature cottonwoods. If the highly flammable bark is ignited, it will debark the entire tree. Mature trees do not reprout. Younger trees are easily topkilled, but can still resprout. Mature cottonwood stands might have been, to a large degree a human artifact, i.e. they were protected by native managers. Associated “seral stage” trees, e.g. green ash, elm, hackberry, also are quite fire intolerant and successional pathway could only exist in virtual absence of fire, human regulated (John Ortman, TNC, personal communication).

Fire Frequency

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Severity** | **Avg FI** | **Percent of All Fires** | **Min FI** | **Max FI** |
| Replacement | 241 | 21 |  |  |
| Moderate (Mixed) | 94 | 54 |  |  |
| Low (Surface) | 201 | 25 |  |  |
| All Fires | 51 | 100 |  |  |

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is the central tendency modeled. Percent of all fires is the percent of all fires modeled in that severity class. Minimum and Maximum FIs show the relative range of fire intervals as estimated by model contributors, if known.

Scale Description

This system consists of a landscape adequate in size to contain natural variation in vegetation and disturbance regime. This BpS occurred in a linear dimension along the Missouri River floodplain and Little Missouri River (MZ30), with smaller areas covered in tributary rivers and streams. Wetland complexes include oxbow lakes, slough, and marshes.

Adjacency or Identification Concerns

BpS 1469 Eastern Great Plains Floodplain Systems, was lumped into this system. 1469 should not be mapped or modeled for this system.

This system is easily identified by using the floodplain which is covered by a 10yr event. Surrounding vegetation could vary from forested to grass prairie transition or bare rock or rock outcrops for instance in the Badlands, White River in South Dakota, and on the Cheyenne. It is adjacent to grassland with some woody draws in the river breaks. In the western part of MZ20, there could be narrowleaf cottonwood and hybrids between this system and narrowleaf.

This system might be very difficult to distinguish from 1469 Eastern Great Plains Floodplain Systems. There is actually only a Midwestern Floodplain and a Great Plains Floodplain, not an Eastern and Western Great Plains Floodplain. The Missouri downstream from Yankton or even Fort Randall might qualify as Midwestern Floodplain. This 1162 Western Great Plains Floodplain is akin to Great Plains Floodplain, whereas 1469 Eastern Great Plains Floodplain is akin to Midwestern Floodplain. It's difficult to determine geographically where the Western model ends and the Eastern model starts, but probably around Yankton, South Dakota or perhaps up to Fort Randall Dam might be a good dividing line for Eastern vs. Western on the Missouri.

Russian olive and tamarisk may be invaders. Tamarisk comes in with cottonwood and willow in earliest post-disturbance stage. Russian olive might affect later successional stages, after 10yrs, usually at approximately the time that green ash and Rocky Mountain juniper come in. Rocky Mountain juniper also invades along the Little Missouri River in MZ29.

Eastern redcedar is invasive in the floodplain forest along the Missouri at Yankton and below, and on reaches farther upstream. Indications are that eastern redcedar would have been less prevalent historically than today due to fires and less grazing pressure. Eastern redcedar has increased on floodplains especially due to fire suppression. Also, flood control and channel degradation have been a dominant influence favoring historic redcedar increases on the Missouri River floodplain, at least below Yankton. Many of redcedar trees on river below Yankton appear to be 30-40yrs old, tying in well with the period that the dams have been in place. Frequent flooding likely kept redcedar scarce on lower floodplain surfaces in the pre-dam era. How far north and west eastern redcedar would have occurred along our rivers originally is questionable (Gary Larson, personal communication).

Leafy spurge, Smooth brome, Canada thistle, might invade also, especially along lower reaches. Russian knapweed might also invade.

The natural flooding frequencies have been changed by the modern water control structures (dam and irrigation projects). Flooding intensity has been altered by construction of small impoundments on tributaries as well as larger impoundments on the main-stem rivers. The mainstem Missouri effectively does not flood any more. Decreased flood frequency along the Little Missouri River decreased cottonwood abundance and increased distribution of silver sage in MZ29 currently. However, this trend has just started, i.e., increase of silver stage today vs. historically.

Agricultural activities have change seral development and introduced invasive plant species to the BpS.

Woodcutters along the system operated from the earliest days (1860s) to supply wood to the paddle wheelers plying the river. They cut many of the early stands along the river and perhaps threw the balance of this system.

There are thousands of smaller dams on watersheds in addition to the large control structures that are altering hydrology today.

American elms are mostly gone today in some areas. On the river downstream of Yankton, however, elm is still a very common species, but does not grow to be a large tree anymore because of Dutch Elm Disease. It is likely, however, that the importance value and average diameter and height of elm has decreased substantially.

Livestock grazing is now different versus historically. The effects of cattle versus bison grazing on the floodplains is very different.

Currently, unpalatable sagebrush cover might be higher today, but chokecherry and associates might be getting wiped out. Bison would have grazed on top and wouldn’t have hung out in the floodplain, whereas cattle are there regularly. Depending on management, cows can graze all tree and shrub seedlings, and the seedling re-establishment is episodic, and now re-establishment is stretched out further due to the livestock. They are removing much of the woody vegetation, and they are also hammering the grassland more intensely (Dave Ode, personal communication).

Johnson (1992), in a study of Missouri River floodplain forests in central North Dakota, determined that the pre-settlement forest was, in fact, dominated by early successional stages. He reports that young pioneer stands (<40yrs. old) comprised 47% of the forest, while older pioneer stands (40-80yrs. old) comprised 25% of the forest; that transitional forest (80-150yrs old) comprised 21% of the forested acreage and that equilibrium stands (dominated by green ash, elm, oak, etc.) (>150yrs old) comprised only 7% of the forested acreage. Johnson (1992) also demonstrated that with construction of Garrison Dam and subsequent cessation of flooding, there is a continuing shift to older forest stages and very little recruitment of new, early successional forest; the very types that once dominated the Missouri River floodplain and provided habitat for its varied native wildlife. (Ode 2004).

Over the past 37yrs, much has changed in the cottonwood forest of LaFramboise Island in South Dakota. As the density of cottonwoods has declined (at a rate of about two per acre per year), the number of junipers and, to some extent, green ash have dramatically increased. In cottonwood forests throughout much of the upper Missouri River Valley, green ash is one of the most important tree species to colonize cottonwood forests and, over time, becomes the dominant forest tree (Ode 2004). Whatever the dominance of green ash in the future forest, it will likely be overwhelmed if not over-shadowed by the massive number of junipers which are now developing in the LaFramboise Island forest understory (Ode 2004). Cottonwood is declining.

Junipers are notoriously vulnerable to fire. On the presettlement landscape of the northern plains, where prairie fires were frequent events, juniper woodlands were restricted to fire-protected environments like river breaks, badland escarpments, buttes, and islands (Ode 2004).

This system should be distinguished from BpS 1159 by geographic range/ecoregions. The Great Plains Floodplain systems are in the Northwestern Glaciated Plains and the Northern Great Plains; the Rocky Mountain Montane Riparian systems are in the lower elevations, i.e., not alpine, of the Northern and Middle Rockies, some of which occur as isolated mountain ranges in the Great Plains. Broadly generalized, the Great Plains Floodplain systems typically have broader floodplains and more terrace development.

Also - montane riparian systems of central Montana and probably the Black Hills, too, will have steeper gradients, narrower floodplains, and be dominated by *Populus angustifolia* or *P. X acuminata* (the hybrid between plains and narrowleaf cottonwood), as opposed to *P. deltoides* for Great Plains floodplains. Rivers like the Powder and Tongue start as montane rivers and become Great Plains rivers.

There might be some difficulty distinguishing the Floodplain Systems from the Riparian from the Wooded Draw/Ravines, and where to assign smaller, second and third order prairie streams. The second and third order prairie streams can sometimes have cottonwood and be like small rivers (Riparian, Floodplain); sometimes they are dominated by other woodies such as water birch, boxelder, green ash (Wooded Draw/Ravine) and willows, depending on how far east you go; sometimes they have very few woody plants other than silver sagebrush. Drainages that just don't have the area to get a good flood would probably have been some sort of woody draw, dominated by green ash or other woodies like hawthorn or chokecherry in the more western part of the Great Plains. In terms of assigning the drainage to one or the other type of system would depend on basin size.

Rivers and streams that have had impoundments (current conditions) for 50yrs or more probably have more Class D and E than presettlement but less Class A and B. Class A and B currently has tamarisk. Class C and D have Russian olive currently. Several exotics, such as Canada thistle, Kentucky bluegrass and quackgrass are ubiquitous in Classes B through E currently.

Issues or Problems

Assumptions: Rapid Assessment model was developed with the recognition that the Great Plains Floodplain forest (cottonwood-willow community) is a seral community. This seral community is most affected by fluvial geomorphic processes such as flooding, avulsion and deposition, and channel movement. The model does include shallow wetlands, sloughs or oxbows. Deep water habitat and the wetted width of the active river were not included in the model. Flood frequency for a class is based on location on the floodplain, with higher terraces being subject to longer flood cycles.

Native Uncharacteristic Conditions

Rivers such as the Missouri below Fort Peck Dam and the Big Horn and Tongue below their dams probably have more late-seral and less early-seral vegetation because of the reduced flooding frequency and severity.

Comments

For MZ38 this model was adopted from the same BpS in MZ31 by Randy Swaty (rswaty@tnc.org). Only minor editing of the description was done to fit the geographic range to MZ43 so modelership was not changed.

Succession Classes

**Mapping Rules**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Upper Layer Lifeform** | **Height (m)** | **Canopy Cover (%)** | | | | | | | | | |
| **0-10** | **11-20** | **21-30** | **31-40** | **41 - 50** | **51-60** | **61-70** | **71-80** | **81-90** | **91-100** |
| Herb | 0-0.5 | UN | UN | UN | UN | UN | UN | UN | UN | UN | UN |
| Herb | 0.5-1.0 | UN | UN | UN | UN | UN | UN | UN | UN | UN | UN |
| Herb | >1.0 | UN | UN | UN | UN | UN | UN | UN | UN | UN | UN |
| Shrub | 0-0.5 | E | E | E | E | UN | UN | UN | UN | UN | UN |
| Shrub | 0.5-1.0 | E | E | E | E | UN | UN | UN | UN | UN | UN |
| Shrub | 1.0-3.0 | E | E | E | E | UN | UN | UN | UN | UN | UN |
| Shrub | >3.0 | E | E | E | E | UN | UN | UN | UN | UN | UN |
| Tree | 0-5 | A | A | A | A | A | UN | UN | UN | UN | UN |
| Tree | 5-10 | B | B | B | B | B | B | B | D | D | D |
| Tree | 10-25 | B | B | B | B | B | B | B | D | D | D |
| Tree | 25-50 | UN | UN | UN | UN | UN | UN | C | C | UN | UN |
| Tree | >50 | UN | UN | UN | UN | UN | UN | C | C | UN | UN |

Succession class letters A-E are described in the Succession Class Description section. Some classes use a leafform distinction where a qualifier is added to the class letter: Brdl (broadleaf), Con (conifer), or Mix (mixed conifer and broadleaf). UN refers to uncharacteristic native or a combination of height and cover that would not be expected under the reference condition. NP refers to not possible or a combination of height and cover which is not physiologically possible for the species in the BpS.

**Description**

Class A 14 Early Development 1 - All Structures

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PODE3 | Populus deltoides | Eastern cottonwood | Upper |
| SAEX | Salix exigua | Narrowleaf willow | Upper |
| SALU2 | Salix lutea | Yellow willow | Upper |
| SCHOE6 | Schoenoplectus | Bulrush | Low-Mid |

Description

This class is created by deposition, stream meander changes, point bar formation and scouring.

The upper layer lifeform is comprised of a seedling and sapling shrub (willows) and tree component and dominated by a young canopy of tree saplings and shrubs after a few years. Trees might be more abundant/frequent. *Salix amygdaloides* (peachleaf willow) is also an upper layer indicator species.

This class consists of Sandbar willow. *Salix* interior is invariably the first which makes its appearance on the newly made lands on the borders of the Mississippi and Missouri, and seems to contribute much towards facilitating the operation of raising this ground still higher; they grow remarkably close and in some instances so much so that they form a thicket almost impenetrable (from Meriwether Lewis during the Lewis & Clark expedition in 1804 to 1806. From Ode 2004).

This includes pioneer tree and shrub species of cottonwoods and willows. The understory is highly variable and consists of bare sand, annuals, or perennial hydrophytes. Species would include various grass, sedges, and rushes. Annuals become less and less common after 10yrs as the rhizomatous perennials take hold. There is an herbaceous understory of sedges (bulrushes) and native annuals in wet areas. In the early few years of this stage, most of the area is bare sand.

Most of area is seasonally flooded. Much bare, wet-alluvium habitat for cottonwood establishment is created each year during spring floods. However, most all of these will be swept away by the next year's flood in the early part of this class. It is probably only every decade or so that flooding occurs up high enough on point bars and low terraces to establish cottonwoods and then allow them to escape flooding until they are large enough to persist in the early part of this class.

During the second part of this class minor flooding occurs frequently, advancing this stage to the next; deposition causes the terrace to build and become higher and drier. This was modeled as alternate succession. Lack of flooding actually maintains the stage.

Major flooding occurs bringing it back to the beginning of this stage. This was modeled as wind/weather stress.

Beaver disturbance occurs in this class. The closer to the river, the more likely it is. It was modeled as "optional 1". Beavers, however, do not have as much of an impact in stands less than 10yrs old unless there is nothing else in the area. Beaver activity is quite variable. It was modeled as maintaining this class.

This class succeeds to the mid-development closed stage.

Johnson (1992) states that young pioneer stands (<40yrs. old) comprised 47% of the forest historically.

*Maximum Tree Size Class*  
Sapling >4.5ft; <5"DBH

Class B 28 Mid Development 1 - Closed

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PODE3 | Populus deltoides | Eastern cottonwood | Upper |
| SAAM2 | Salix amygdaloides | Peachleaf willow | Mid-Upper |
| SALU2 | Salix lutea | Yellow willow | Middle |
| FRPE | Fraxinus pennsylvanica | Green ash | Low-Mid |

Description

This stage develops as the stand starts to mature. This community tends to be partially opened, with scattered cottonwoods and willows. Stands of cottonwoods can be fairly dense, although there are usually some openings. The shrub layer is highly variable and may include species such as rose, snowberry, chokecherry, dogwood.

Green ash begins to establish in cottonwood stands after a few decades (Lesica and Miles 1999).

The understory vegetation is highly variable. This class succeeds to a late closed stage.

Willows slow current and create deposition on top. The vegetation helps anchor and causes deposition which decreases flood frequency. Flooding leading to deposition occurs, promoting succession to the next stage by raising the level of the terrace (modeled as alternate succession). Major flooding also occurs also occurs as often bringing this class back to the early Class A stage (modeled as wind/weather stress).

Replacement fires were modeled. It would probably only burn in drought, as fires would be very rare. It has been suggested that stand replacing fires might not occur in this class because it might be too wet for fire. However, due to lack of data, replacement fires were kept in the model. It is questionable whether replacement fire would set this stage back to the beginning of Class A, as the terrace would be too high and dry to provide conditions for successful establishment of cottonwood and willow from seed. If the cottonwoods resprouted, it would be more like the middle of Class A because the understory would be more mature than the beginning of Class A; if the cottonwoods didn't resprout, it would probably just be a willow stand. Replacement fire was however modeled as taking this class to Class A.

Low severity and mixed fire also occur and would not cause transition to another stage.

Beaver disturbance occurs in this class. The closer to the river, the more likely it is. It was modeled as "optional 1". Beaver activity is quite variable. It was modeled infrequently, thus maintaining this class.

It has been suggested that Native Americans likely burned (low severity fires) these areas more often. However, another reviewer questioned that and stated that they probably didn’t burn these areas but rather the surrounding area, since this area would be too difficult to burn due to too much shade and humidity. Also, some sites were likely heavily grazed by bison (low severity fire sites) and horses near camps. However, the model was retained as is, as no confirming feedback was received.

*Maximum Tree Size Class*  
Medium 9-21"DBH

Class C 36 Late Development 1 - Closed

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PODE3 | Populus deltoids | Eastern cottonwood | Upper |
| SYOC | Symphoricarpos occidentalis | Western snowberry | None |
| FRPE | Fraxinus pennsylvanica | Green ash | Middle |

Description

This class is a mature, late seral closed canopy cottonwood floodplain forest. Overstory is dominated by cottonwood and green ash. Box elder is a frequent component of this class for MZs 39 and 40 but is not as common as green ash. (Some modelers/reviewers thought that the system is becoming drier in this class allowing western wheatgrass to come in; however, others questioned that.) Tree height maximum probably only goes to approximately 30-35m. Western portions will be shorter.

Ecological studies along the Missouri River in central North Dakota have documented a similar successional pattern as that for at least four studies along the Missouri River in southeastern South Dakota, which have described aspects of a successional sequence that begins with colonization by cattails or sandbar willow, develops through transitional phases to a plains cottonwood dominated forest, and finally, in the absence of stand replacing floods, develops into a mixed deciduous forest containing aging cottonwoods, green ash, boxelder, bur oak (Johnson 1950, Heckel 1963, Wilson 1970), and American elm (Johnson, et al. 1976). (Ode 2004). This was therefore modeled as a successional pathway to Class D. Some cottonwood stands follow the successional pathway and proceed to Class E’s silver sage component, which was modeled as alternate succession. Others have enough green ash that the next class, in this case Class D, is dominated by green ash and *Symphoricarpos occidentalis.* Some stands would be a mosaic of these two late-seral types.

This class can succeed to Class D. This class probably only succeeds to Class E’s silver sage component with high flood and not a frequent occurrence, thus for MZs 39 and 40, it was modeled as alternate succession instead of the main successional pathway as was done in Montana and western Dakota map zones. Historically, this system might have even succeeded to juniper. When there is a 100-year flood and high sand deposits occur, cottonwoods die, and then dry stands occur. It is then too dry for green ash, so it might succeed to juniper. In these cases, it was islands – so they were protected from fire. Those that would form on terraces would probably be affected by fire. But islands didn’t burn and so juniper was retained.

Note that the forest might not succeed to stage E in eastern South Dakota, and rather it might remain in Class C or D. Class E is more appropriate for western parts of the map zones where later successional species are scarcer.

Minor flooding occurs. Minor flooding raises the level of the terrace. Because this is the last stage in this cottonwood portion of the system, this minor flooding was modeled as wind/weather stress, causing no transition. Major flooding occurs bringing this class back to Class A. This was modeled as wind/weather stress.

Replacement fire occurs and takes this class to Class E’s silver sage component was originally modeled in Montana and western Dakota map zones. However, because that fire was speculative, and because review for MZs 39 and 40, it was thought that those events do not occur often, and because too much was thought to be going into Class E, that replacement fire was removed for MZs 39 and 40. It is thought that drought might convert this system to sagebrush, but that is speculative, and geographical climaxes vary.

Low severity fire was also modeled as it was in Class B, causing no transition. Mixed severity fire was also included with the same probability as low severity. It is thought that mixed severity fire might cause a more open, drier stand that would allow invasion of silver sagebrush earlier, bringing it to E earlier; however, that was not modeled for MZs 39 and 40, as it is speculative.

Optional 2 in this class represents erosional processes of river meandering that would bring this class eventually back to Class A. The class/system will first be part of the river, but then will succeed to class A or a point bar state. This occurs with a frequency of several hundred years and was modeled.

River meanders back and begins to cut away at the banks whereon a mature or old-growth stand of POPDEL exists and the living trees slowly are undercut and ultimately fall into the stream.

Beaver disturbance occurs in this class. The closer to the river, the more likely it is. It was modeled as "optional 1". Beaver activity is quite variable and modeled as maintaining this class.

Johnson (1992) states that older pioneer stands (40-80yrs. old) comprised 25% of the forest; that transitional forest (80-150yrs old) comprised 21% of the forested acreage and that equilibrium stands (dominated by green ash, elm, oak, etc.) (>150yrs. old) comprised only 7% of the forested acreage historically.

*Maximum Tree Size Class*  
Very Large >33"DBH

Class D 11 Late Development 2 - Closed

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| FRPE | Fraxinus pennsylvanica | Green ash | Middle |
| ACNE2 | Acer negundo | Boxelder | Middle |
| PODE3 | Populus deltoides | Eastern cottonwood | Upper |
| SYOC | Symphoricarpos occidentalis | Western snowberry | Lower |

Description

The trees are actually shorter as one moves west. Green ash and cottonwood in the central and western Dakotas are almost half the size of those in the Midwest.

This class was based on R4NOFP class E. It is found along the upper terrace that has been protected from most flood events, except for rare high intensity flooding. Species composition increases towards south and east within the region. Overstory species include hackberry, green ash, and elm. Understory species include vines and poison ivy.

In the absence of stand replacing floods, this class is what has developed - a mixed deciduous forest that may contain aging cottonwoods, green ash, American elm, boxelder, bur oak, and eastern redcedar (Johnson 1950, Heckel 1963, Wilson 1970), which is more prominent in the East but still present in the Dakotas. Ecological studies along the Missouri River in central North Dakota have documented a similar successional pattern ultimately resulting in a forest dominated by green ash, boxelder, bur oak, and American elm (Johnson, et al. 1976). (From Ode 2004).

Class D’s components of hackberry, slippery elm and bur oak are present downstream from Yankton in the Dakotas. These species occur in central to eastern North Dakota. In western North Dakota (and probably much of western South Dakota, too) species are green ash, American elm, boxelder and eastern redcedar and *Juniperus scopulorum*.

Hansen et al. (1984) state that other dominants are *Toxicodendron rydbergii* and *Elymus canadensis.*

The FRPE/SYOC association is an edaphic climax on the floodplain adjacent to the Little Missouri River and its major tributaries. PODE currently dominates many stands but is no longer reproducing. It will be replaced by FRPE. The larger trees, some 6-7dm DBH are PODE, but the young trees establishing in the stands are FRPE. JUSC is tallied with the tree species, although it's an understory species in the closed forest. Its current abundance is attributed to adequate light penetrating to the shrub and herb layers of the community as a result of wide spacing of the old *Populus*. Along the Missouri River, in central North Dakota, southest South Dakota, and near Omaha, Nebraska, PODE is a pioneer species and is replaced successionally by various combos of *Fraxinus, Ulmus, Acer,* and *Celtis*. Among the grasses, CALO, ELCA, MURA are important (Hansen et al. 1984).

The disturbances are those from R4NOFP: Major flooding events can bring this class back to A, modeled as wind/weather stress. Flooding events can also cause a transition back to C modeled as wind/weather stress.

Mixed fire occurs but causes no transition.

Dominants of the green ash/western snowberry stands can resprout after fire. However, a very hot fire can kill the green ash (Lesica 2003), in which case it would probably become a stand of western snowberry-silver sagebrush-western wheatgrass (not modeled here).

*Maximum Tree Size Class*  
Medium 9-21"DBH

Class E 11 Late Development 3 - Closed

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| ARCA13 | Artemisia cana | Silver sagebrush | Upper |
| SYOC | Symphoricarpos occidentalis | Western snowberry | Upper |
| PASM | Pascopyrum smithii | Western wheatgrass | Middle |

Description

Note that the forest might not succeed to this stage E in eastern South Dakota, and rather it might remain in Class C or D. Class E is more appropriate for western parts of the map zones where later successional species are scarcer.

This stage in Montana and western Dakotas map zones was modeled as a silver sagebrush community. For MZs 39 and 40, it is thought that there are a few historical alternative ends, of which silver sage is only one. Therefore, stage E is a combination of the alternative ends. Silver sage is a common terrace shrub, but the events causing this system to move there are infrequent, and therefore the previous 25% in this Class E from Montana map zones did not apply in the Dakotas. Another alternative end is this system going to Juniper. These are examples of where the successional path might take a different turn due to rare flood events or geographically varying climaxes and variations dependent on habitat.

The cedar stage/forest is also another stage that might have been present historically but not anymore, in all stages of this system (Dave Ode, personal communication).

The silver sagebrush climax community occurs on river terraces and along larger streams. It has been noted (Steve Cooper, personal correspondence) that the usual case in this system is for plains cottonwood to die out and for the stand to go to silver sagebrush domination with western wheatgrass in the undergrowth or western snowberry and rose (*Rosa* spp) with grasses (mostly PASSMI). That is what is therefore modeled here. It is thought that before this stage gets to silver sagebrush, there might be an intermediate stage dominated by western wheatgrass and snowberry before silver sagebrush establishes in significant amounts. However, due to the limitations of the 5-box model, this intermediate stage was not modeled.

This stage starts at a late age to account for the low probability of the alternate successional pathway from C.

This class is less likely to have depositional flooding than other stages. It was therefore not modeled here.

Major flooding events were modeled as wind/weather stress occurs a brings this class back to A.

Optional 2 in this class represents erosional processes of river meandering that would bring this class eventually back to Class A. The class/system will first be part of the river, but then will succeed to Class A or a point bar state. This occurs with a frequency of several hundred years.

Replacement fire was modeled similar to other silver sage communities, but maintaining this stage, as this class is stable, and the silver sagebrush resprouts and thus maintains this stage.

Note for mappers: although height and cover overlap with Class A, species are completely different. This is no longer a PODE3 community.

It is thought that this stage might be more prevalent currently vs historically due to impoundments increasing the silver sage distribution.

It is questionable as to how much this class occupied of the historic landscape. In Montana and western Dakota zones, it was modeled as 25%; however, it was thought that that was too much for the Dakotas.

Johnson (1992) states that older pioneer stands (40-80yrs. old) comprised 25% of the forest; that transitional forest (80-150yrs old) comprised 21% of the forested acreage and that equilibrium stands (dominated by green ash, elm, oak, etc.) (>150yrs.old) comprised only 7% of the forested acreage historically.

*Maximum Tree Size Class*  
None

Model Parameters

Deterministic Transitions

|  |  |  |  |
| --- | --- | --- | --- |
| **From Class** | **Begins at (yr)** | **Succeeds to** | **After (years)** |
| Early1:ALL | 0 | Mid1:CLS | 14 |
| Mid1:CLS | 15 | Late1:CLS | 50 |
| Late1:CLS | 51 | Late2:CLS | 149 |
| Late3:CLS | 100 | Late3:CLS | 999 |
| Late2:CLS | 150 | Late2:CLS | 999 |

Probabilistic Transitions

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Disturbance Type** | **Disturbance occurs In** | **Moves vegetation to** | **Disturbance Probability** | **Return Interval (yrs)** | **Reset Age to New Class Start Age After Disturbance?** | **Years Since Last Disturbance** |
| Optional 1 | Early1:ALL | Early1:ALL | 0.01 | 100 | No | 0 |
| Wind or Weather or Stress | Early1:ALL | Early1:ALL | 0.02 | 50 | Yes | 0 |
| Alternative Succession | Early1:ALL | Mid1:CLS | 0.05 | 20 | Yes | 0 |
| Surface Fire | Mid1:CLS | Mid1:CLS | 0.005 | 200 | No | 0 |
| Mixed Fire | Mid1:CLS | Mid1:CLS | 0.005 | 200 | No | 0 |
| Replacement Fire | Mid1:CLS | Early1:ALL | 0.0067 | 149 | Yes | 0 |
| Optional 1 | Mid1:CLS | Mid1:CLS | 0.01 | 100 | No | 0 |
| Alternative Succession | Mid1:CLS | Late1:CLS | 0.02 | 50 | Yes | 0 |
| Wind or Weather or Stress | Mid1:CLS | Early1:ALL | 0.02 | 50 | Yes | 0 |
| Alternative Succession | Late1:CLS | Late3:CLS | 0.002 | 500 | Yes | 0 |
| Wind or Weather or Stress | Late1:CLS | Early1:ALL | 0.005 | 200 | Yes | 0 |
| Optional 2 | Late1:CLS | Early1:ALL | 0.005 | 200 | Yes | 0 |
| Mixed Fire | Late1:CLS | Mid1:CLS | 0.01 | 100 | Yes | 0 |
| Surface Fire | Late1:CLS | Late1:CLS | 0.01 | 100 | No | 0 |
| Optional 1 | Late1:CLS | Late1:CLS | 0.01 | 100 | No | 0 |
| Wind or Weather or Stress | Late1:CLS | Late1:CLS | 0.1 | 10 | No | 0 |
| Wind or Weather or Stress | Late2:CLS | Early1:ALL | 0.004 | 250 | Yes | 0 |
| Wind or Weather or Stress | Late2:CLS | Late1:CLS | 0.005 | 200 | Yes | 0 |
| Mixed Fire | Late2:CLS | Late2:CLS | 0.05 | 20 | No | 0 |
| Optional 2 | Late3:CLS | Early1:ALL | 0.0025 | 400 | Yes | 0 |
| Wind or Weather or Stress | Late3:CLS | Early1:ALL | 0.004 | 250 | Yes | 0 |
| Replacement Fire | Late3:CLS | Late3:CLS | 0.02 | 50 | No | 0 |

Optional Disturbances

Optional 1: beaver

Optional 2: erosional processes of river meandering

References

Auble, G.T. and M.L. Scott. 1998. Fluvial disturbance patches and cottonwood recruitment along the upper Missouri River, MT. Wetlands 18:546-556.

Boggs, K. and T. Weaver. 1994. Changes in vegetation and nutrient pools during riparian succession. Wetlands 14:98-109.

Bovee, K.D. and M.L. Scott. 2002. Implications of flood pulse restoration for populus regeneration of the Upper Missouri River. River Research and Applications 18:287-298.

Bragg, T.B. and A.K. Tatschl. 1977. Changes in flood-plain vegetation and land use along the Missouri River from 1826 to 1972. Environmental Management 1(4):343-348.

Cleland, D.T.; Freeouf, J.A.; Keys, J.E.; Nowacki, G.J.; Carpenter, C.A.; and McNab, W.H. 2007. Ecological Subregions: Sections and Subsections for the conterminous United States. Gen. Tech. Report WO-76D [Map on CD-ROM] (A.M. Sloan, cartographer). Washington, DC: U.S. Department of Agriculture, Forest Service, presentation scale 1:3,500,000; colored

Cooper, D.J., D.C. Andersen and R.A. Chimner. 2003. Multiple pathways for woody plant establishment at local to regional scales. Journal of Ecology 91:182-196.

Friedman, J.M., W.R. Osterkamp and W.M. Lewis, Jr. 1996. Channel narrowing and vegetation development following a Great-Plains flood. Ecology 77:2167-2181.

Friedman, J.M., W.R. Osterkamp, M.L. Scott and G.T. Auble. 1998. Downstream effects of dams: regional patterns in the Great Plains. Wetlands 18:619-633.

Friedman, J.M. and V.J. Lee. 2002. Extreme floods, channel change and riparian forests along ephemeral streams. Ecological Monographs 72:409-425.

Girard, M.M., H. Goetz and A.J. Bjugstad. 1989. Native woodland habitat types of southwestern North Dakota. USDA Forest Service Research Paper RM-281.

Gregory, Stanley V., Frederick J. Swanson, W. Arthur McKee and Kenneth W. Cummins. 1991. An Ecosystem Perspective of Riparian Zones. Bioscience 41:540-551.

Hansen, P.L, G.R. Hoffman and A.J. Bjugstad. 1984. The vegetation of Theodore Roosevelt National park, North Dakota: a habitat type classification. GTR RM-113. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. 35 pp.

Hansen, P.L., R.D. Pfister, K. Boggs, B.J. Cook, J.Joy and D.K. Hinckley. 1996. Classification and management of Montanas riparian and wetland sites. Montana Forest and Conservation Experiment Station. Missoula, Montana. Miscellaneous publication no. 54. 485 pp.+ appendices.

Heckel, Millard C. 1963. An ecological study of a floodplain forest. M.A. Thesis, University of South Dakota, Vermillion, SD. 21 pp.

Hughes, F.M.R. 1994. Environmental change, disturbance and regeneration in semi-arid floodplain forests. 321-345. In: Millington, A.C. and K. Pye, edss. Environmental change in drylands: biogeographical and geomorphological perspectives. John Wiley and Sons, New York, NY.

Johnson, Donald F. 1950. Plant succession on the Missouri River floodplain near Vermillion, South Dakota. M.A. Thesis. University of South Dakota, Vermillion, SD.

Johnson, W.C. 1992. Dams and riparian forests: case study from the upper Missouri River. Rivers 3(4):229-242.

Johnson, W.C. 1994. Woodland expansion in the Platte River, Nebraska: patterns and causes. Ecological Monographs 64:45-84.

Johnson, W.C., R.L. Burgess and W.R. Keammerer. 1976. Forest overstory vegetation and environment on the Missouri River floodplain in North Dakota. Ecological Monograph 46(1):59-84.

Jones, W.M. 2003. Milk and Lower Marias River Watersheds: Assessing and maintaining the health of wetland communities. Prepared for the U.S. Bureau of Reclamation. Montana Natural Heritage Program. Helena, MT. 17 pp. + appendices..

Katz, G.L., J.M. Friedman and S.W. Beatty. 2005. Delayed effects of flood control on a flood-dependent riparian forest. Ecological Applications 15(3):1019-1035.

Lesica, P. 2003. Effects of wildfire on recruitment of Fraxinus pennsylvanica in eastern Montana woodlands. American Midland Naturalist 149:258-267.

Lesica, P. and S. Miles. 1999. Russian olive invasion into cottonwood forests along a regulated river in north-central Montana. Can. J. Bot. 77:1077-1083.

Lesica, P. and S. Miles. 2004. Beavers indirectly enhance the growth of Russian olive and tamarisk along eastern Montana rivers. Western North American Naturalist 64(1):93-100.

Lytle, D.A. and D.M. Merritt. 2004. Hydrologic regimes and riparian forest: a structured population model for cottonwood. Ecology 85(9):2493-2503.

NatureServe. 2007. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Databases. Arlington, VA, U.S.A. Data current as of 15 April 2007.

Noble, M.G. 1979. The origin of Populus deltoides and Salix interior zones

on point bars along the Minnesota River. American Midland Naturalist 102:59-67.

Ode, D.J. 2004. Wildlife habitats of LaFramboise Island: Vegetational change and management of a Missouri River Island South Dakota Game, Fish and Parks Department

Pierre, South Dakota. Wildlife Division Report No. 2004-14.

Richards, K, J. Brasington and F. Hughes. 2002. Geomorphic dynamics of floodplain: ecological implications and a potential modeling strategy Freshwater Biology 47:559-579.

Richter, B.D. and H.E. Richter. 2000. Prescribing flood regimes to sustain riparian

ecosystems along meandering rivers. Conservation Biology 14:1467-1478.

Scott, M.L., J.M. Friedman and G.R. Auble. 1 1996. Fluvial processes and the establishment of bottomland trees. Geomorphology 14:327-339.

Scott, M.L. and G.T. Auble. 2002. Conservation and restoration of semi-arid riparian forests: a case study from the upper Missouri River, Montana, USA. 145-190. In: Flood Pulsing and Wetland Restoration in North America. Middleton, B., ed. John Wiley and Sons, New York, NY.

Scott M.L, G.T. Auble and J.M. Friedman. Flood Dependency of Cottonwood Establishment Along the Missouri River, Montana, USA. 1997. Ecological Applications 7(2):677-690.

Steinauer, G. and S. Rolfsmeier. Terrestrial Natural Communities of Nebraska (Version III - June 30, 2003). Nebraska Natural Heritage Program. Nebraska Game and Parks Commission. Lincoln, NE.

USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (2002, December). Fire Effects Information System. Available at

http://www.fs.fed.us/database/feis/

Weaver, J. E. 1960. Flood plain vegetation of the central Missouri valley and contacts of woodland with prairie. Ecological Monographs 30(1):37-64.

Wilson, Roger E. 1970. Succession in stands of Populus deltoides along the Missouri River in Southeastern South Dakota. The American Midland Naturalist 83(2):330-342.