Proactive River Corridor Definition: Recommendations for a Process-based Approach

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Introduction

A River Corridor is defined as an area around a particular river designated as the area where fluvial processes may operate to sustain key river functions and create and maintain habitat in alluvial river valleys. Channel migration is a vital process to sustain river- and riparian health. It allows the river channel to dynamically adjust to changing inputs of water, sediment, and wood, maintaining a corridor through which flood flows may be conveyed (Church, 2006), produces topographic variability across the floodplain to support diverse aquatic and terrestrial habitats (Jones, 2006; Latterell et al., 2006), is a primary mechanism by which large wood is entrained into larger rivers (e.g. Abbe and Montgomery, 1996, 2003; Brummer et al., 2006; Collins et al., 2012), and ultimately creates and maintains the complexity and diversity in channel and floodplain hydraulics that is necessary for the flourishing of aquatic organisms. When channel migration reaches the edge of the river corridor, it puts pressure on surrounding revetments, often causing them to fail requiring maintenance activity, or erodes surrounding land.

Human development within river valleys has led to extensive flood protection measures such as levees and revetments constraining channel migration. Traditionally many rivers have been managed simply as a channel with adequate conveyance to convey major floods. This led to narrow corridors with very little of their natural habitat diversity which are sensitive to failure due to small changes in flood discharges or sediment supply. This paper presents an example study to define the required corridor width for a suite of flood protection and habitat goals for the Nooksack River, in northwest Washington state, showing how benefits are provide both for the riverine ecosystem and surrounding human communities. For the purpose of this assessment, flood management objectives were defined as follows:

- Reduce property and infrastructure damage during moderate (5-100 yr) events
- Maintain large-scale flow splits between channel and overbank flow paths during 100 yr event
- Maintain productivity of surrounding agricultural land with a focus on spring snowmelt flood risk
- Manage sediment entering reach to both minimize specific aggradation rate and adverse downstream impacts
- Reduce costs to maintain flood protection infrastructure

Objectives for ecological habitat are typically linked to keystone species such as salmonids in the Pacific Northwest. We use the goals for the river specified by Maudlin (2021), which included assuring a specified percent of natural banks and natural edge habitat area, floodplain connectivity, connected channel migration area, forested islands, side channel length, and area and age distribution of the riparian forest are directly relatable to the river corridor width.

This paper reviews established river corridor concepts, principal processes that create and sustain both flood conveyance capacity and habitat within river corridors, and quantifies rates of key processes for the example river system in order to define how river corridor width affects function of the specified flood management and habitat goals for the characteristic reach.

River Corridor Concepts

An approach to managing the river as a corridor should is intended to provide an effective tool to meet the combined needs of flood and habitat management identified above. There are several existing tools used in Washington State and elsewhere to define River Corridors:

Channel Migration Zone (CMZ) mapping and related land use guidance is a dominant emerging river corridor concept. CMZ mapping seeks to identify the area where lateral channel migration is likely to affect the landscape, usually in a defined future time window. These include extrapolation of average historical channel migration rates, interpretation of topography to identify areas shaped by past channel migration, and evaluation of likely channel responses to individual large flood events. To date, the most advanced programs and guidance in North America have been implemented in the states of Colorado (Colorado Water Conservation Board, 2020), Washington (Rapp and Abbe, 2003; Forest Practices Board, 2004; Legg and Olson, 2014; Olson et al., 2014; Washington Department of Ecology, 2020), and Vermont (Kline and Dolan, 2008), but programs exist in other jurisdictions (See Appendix A of Colorado Water Conservation Board, 2020 for a helpful review). In many cases, the large footprint of the identified hazard area results in such delineation having little practical effect on land use planning.

The FEMA Floodway and Floodplain are the areas needed to convey and store floodwaters delineated as a part of the FEMA floodplain mapping process. The floodplain delineates the area that is expected to be inundated by a flood, with mapping typically focused on areas that have a 1% average chance of exceedance (ACE) in any given year (commonly called the 100-year flood) and 0.2% ACE. The Regulatory Floodway is defined as the portion of the channel of a river and adjacent land areas that must be reserved to convey the discharge of the design flood down the valley without cumulatively increasing the water surface elevation more than a designated height. Characteristically, local jurisdictions regulate land use within the floodway and floodplain to reduce flood damages.

Shoreline buffers are a protected area adjacent to a river or stream intended to protect the water body from adverse effects of development, forest harvest, agriculture, or other human land uses and are the primary tool for the protection of freshwater systems (Richardson et al., 2012). They support the aesthetic value of the river, support fish habitat function, control sediment inputs, and provide refuge for wildlife. Shoreline buffers are typically delineated from the ordinary high water mark at the edge of the active channel (Budd et al., 1987). Typically shoreline buffer widths are between 35 and 125 ft from the high water mark across different riparian ecosystems as outlined in Table 1. In rivers that actively migrate, erosion can eliminate the function of the buffer. Therefore, these functions must be maintained at the margins of the river corridor for the underlying values to be supported. This may require active protection of the buffer zone from channel migration to allow the persistence of mature vegetation.

Table 1: Widths needed to support key shoreline buffer roles.

Buffer Role	Buffer Width*	Reference
Water Temperature Control	35 to 80 ft 75 to 125 ft	Brazier and Brown (1973) Steinblums et al. (1984)
Food Supply for Benthic Invertebrates	100 ft	Erman et al. (1977)
Large Wood Input	100 ft	Bottom et al. (1983)
Sedimentation Control	100 ft	Erman et al. (1977)
Wildlife Habitat	> 90 ft >300 ft	WADOE (1981) Semlitch et al. (2009)

* These buffer widths extend on either side of the stream from the ordinary high water, so the associated corridor width would be the stream width plus two times the buffer width.

In addition to functioning as wildlife habitat, shoreline buffers and riparian forests may serve as ecological corridors supporting connectivity of surrounding upland habitat areas (e.g. Czochański and Wiśniewski, 2018). The linear-network structure of river corridors enables them to provide strips of habitat to facilitate the movement of species between core habitat areas (Gallé et al., 1995). To function in this role, river corridors need to be suitable for the needs of specific species that may utilize them and to connect to surrounding core habitat areas.

Freedom Space defines the area necessary for the river to ensure both public safety and ecological services and allows those areas to be left free to evolve rather than being forced to flow in a confined corridor shaped by aggressive engineering intervention (Piégay et al., 1996; Malavoi et al., 1998; Bravard et al., 1999; Piégay et al., 2005; Biron et al., 2014; Buffin-Bélanger et al., 2015; Massé et al., 2020). Freedom space combines geomorphic-based channel migration analysis with historic flood inundation assessment in order to understand fundamental formative river processes. In particular, it identifies the importance of the *Meander Belt* as the fundamental area where channel migration should be allowed. This is important because meander waveforms tend to migrate down the valley faster than they shift across the valley so that extrapolation of migration rates to a buffer perpendicular to the slope of the valley—as is the normal practice in CMZ analysis in Washington State—will tend to exaggerate the area needed for channel migration. The freedom space concept is most readily applied to define the area needed to protect the integrity of a relatively unmodified stream (Biron, Personal Communication 2021). In heavily modified streams, lateral migration rates and the character of the meander belt may not reflect conditions needed for healthy river function. In scenarios such as this, it may be possible to determine expected meander amplitudes from empirical approaches (e.g. Jefferson, 1902; Inglis, 1949; Leopold and Wolman, 1960; Carlston, 1965; Ackers, 1970; Lorenz, 1983; Williams, 1986; Annable, 1996; Ward et al., 2002) or to use river conditions from before extensive anthropogenic modification or an analog reach to define an appropriate meander belt width.

River Corridor Processes

Floodplain Rejuvenation

Laterally mobile gravel bedded rivers of the Coastal Pacific Northwest, especially those with high sediment loads, create and maintain their corridors for flood flow conveyance and habitat function through dynamic floodplain formation and erosion processes mediated through the role of riparian forests. In such rivers fine sediment (clay, silt, and sand) accumulates on the floodplain, raising the elevation of that ground and reducing the availability of important side channel and off-channel habitat areas, but this accumulation of fine sediment is balanced by channel migration, in a process called *floodplain rejuvenation* which removes the fine sediment that has accumulated through bank erosion and re-sets low topography through sediment deposition in bars opposite the eroding bank (**Figure 1**).

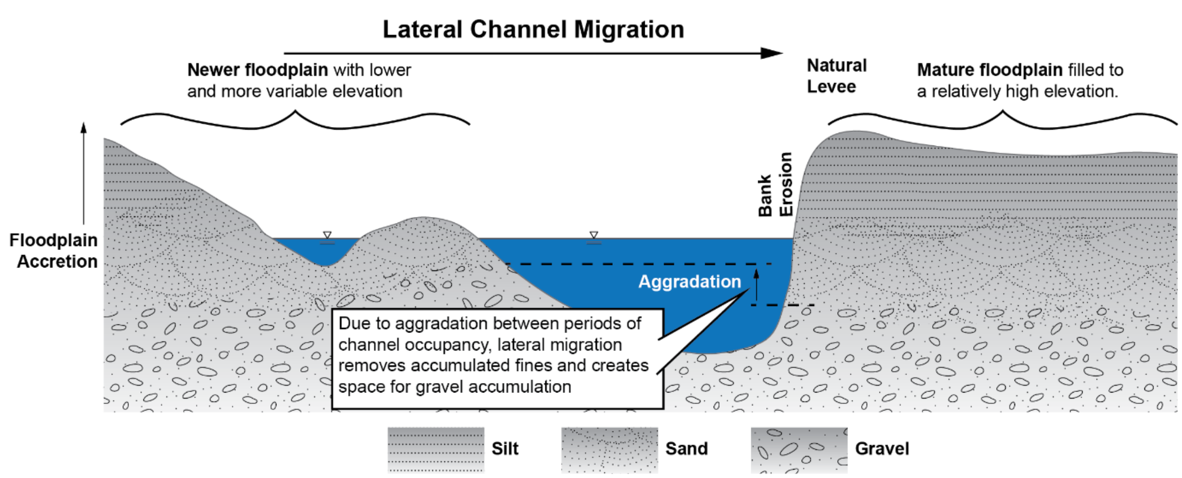

Figure 1: Illustration showing lateral migration rejuvenating low floodplain topography, after Walker (1984).

In an aggrading river with functioning floodplain rejuvenation, dynamic equilibrium is maintained between fine sediment erosion and deposition; but bank erosion removes fine sediment that had accumulated above the gravel deposits that formed when the riverbed had been at a lower elevation and creates space in the valley cross section for long term gravel storage. Narrowing the river corridor can disrupt this dynamic equilibrium in two important ways: If revetments are configured so that they do not create channel migration traps the rate of floodplain turnover increases (reducing age and function of riparian vegetation) as does the specific aggradation rate ((McLean et al., 2013). In contrast, if revetments are arranged so that they trap channel migration (for example, a guided meandering configuration) they can fix the low flow channel in place, resulting in vegetation establishment and increases in ground elevation and roughness of the surrounding floodplain.

Floodplain Habitat and The Role of Large Wood

In addition to maintaining conveyance area for floodwater and providing accommodation space for accumulating gravel and cobble deposits, floodplain rejuvenation processes are vital to sustaining the diversity of floodplain habitat environments and functions characteristic of healthy gravel bed rivers in the Coastal Pacific Northwest. The dynamic interplay between natural lateral channel migration patterns that rejuvenate the floodplain, accretion of fine sediment on the floodplain, and aging of the floodplain forest create the dynamic patch mosaic of floodplain elevations, ages, and vegetation structure necessary for aquatic and riparian life to thrive and for habitat diversity to be maintained (Latterell et al., 2006, Figure 2).

Mature forest patches play a particularly important role: these forests act as riparian buffers around the channel and provide the source of large wood (especially key pieces, which are similar in scale to the width and/or depth of the channel) that changes local hydraulics and channel migration dynamics to create the complexity and diversity of hydraulic environments necessary to support salmonid life. In particular, large wood jams are a key creator of pool habitat and provide the cover and local hydraulic diversity that fish need (e.g. Abbe and Montgomery, 1996; Gurnell et al., 2002; Abbe and Montgomery, 2003; Collins et al., 2012; Scott et al., 2019; Wohl et al., 2019). In addition, they protect patches of the floodplain from rapid channel migration and allow the century-or so needed to grow a forest, providing the locations for future wood supply to the river (Abbe et al., 2003; Micheli et al., 2004; Collins et al., 2012; Abbe et al., 2015). Since key pieces are proportional to channel size (Abbe and Montgomery 2003), the larger the river, the greater the time needed for trees to mature. This equates to reduced rates of floodplain turnover or to physical mechanisms such as logjams that create “hard points” protecting forest patches within the corridor (Abbe and Montgomery 1996; Collins et al. 2012).

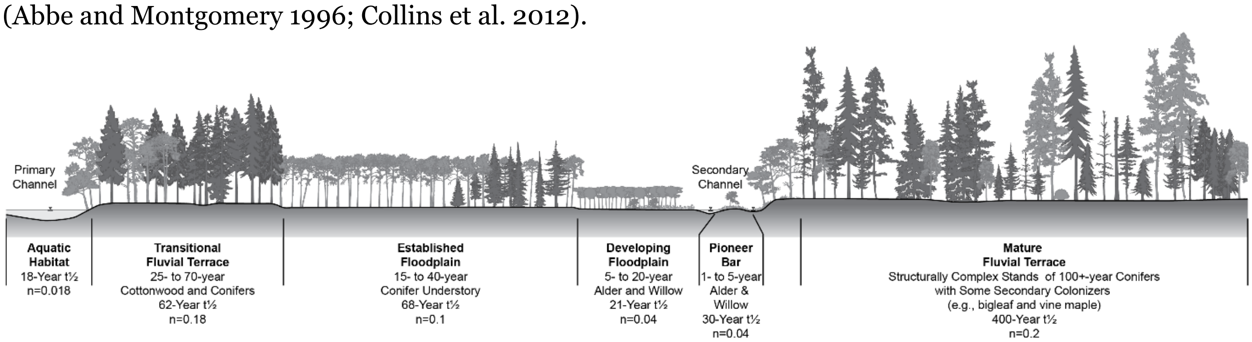

Figure 2: Characteristics of riparian patch types, after Latterell et al. (2006).

Confinement and Constriction

By affecting channel migration dynamics *constriction* and *confinement* of the main channel influence the shape of the channel, availability of floodplain and side channel habitat, and age distribution of the riparian forest.

Constriction (Figure 3A) is defined as the presence of revetments on both banks of the channel that reduce the channel's bankfull width below an appropriate width for the channel if the banks were not protected. It has severe impacts on channel morphology, reducing the width to depth ratio of the channel, simplifying the channel cross section, increasing flow velocity, scour, and the size of the bed material, and removing functioning edge habitat area (Lugo et al., 2015).

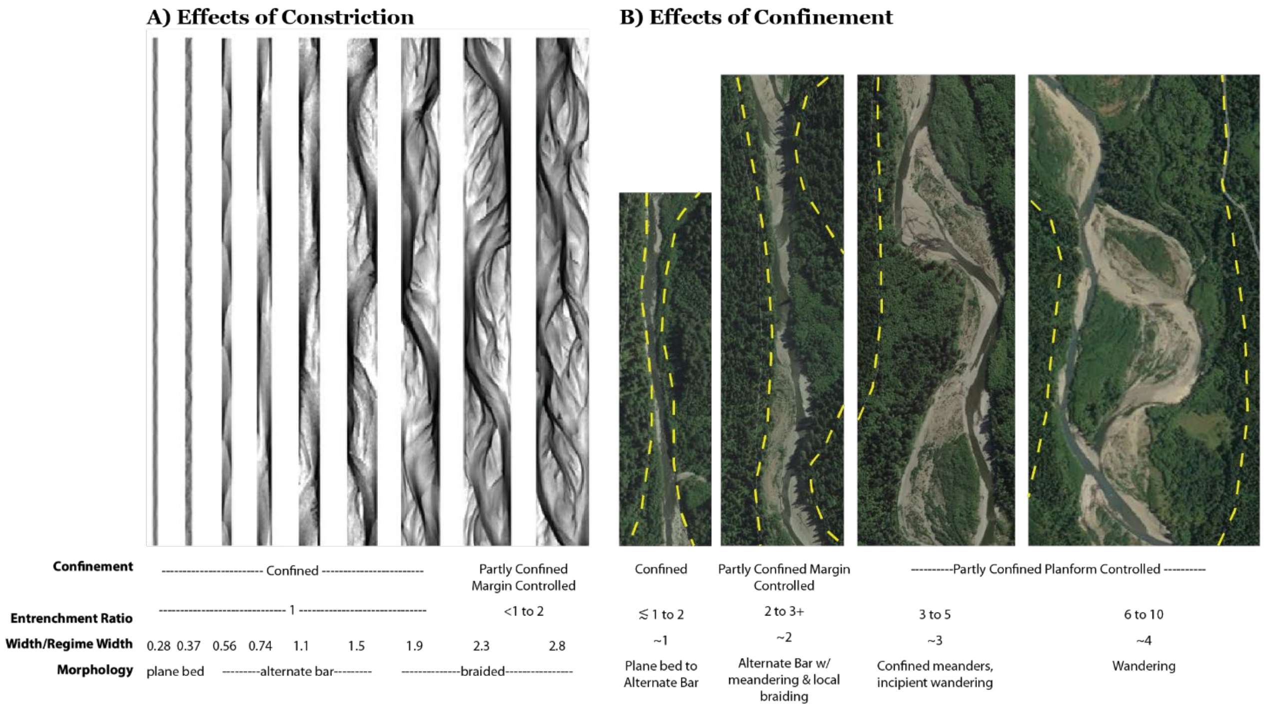

Figure 3: A) Detrended DEMs showing channel morphology for a series of flume runs with constant discharge and bed material and variable constriction. Adapted from Lugo et al. (2015). The expected regime width for the channel was calculated by developing a UBCRM regime model (Eaton et al., 2004; Eaton, 2007) parameterized with the flume slope discharge, bed material grainsize, and a bank strength value of μ=3. **B)** Illustration of the effects of lateral confinement on coastal Pacific Northwest river channel morphology. Yellow dashes indicate the approximate position of confining margins.

Confinement (Figure 3B) is defined as the presence of revetments that prevent lateral channel migration. It can be characterized as either the percentage of either bankline interacting with revetments or other features (e.g. bedrock) that prevent bank erosion (percent confinement of Fryirs et al., 2016) or as a "confinement ratio" which is the ratio between the channel width and the width of the area that can be eroded. Confinement, depending on its degree and the configuration of the confining margins, can act either to increase floodplain turnover rates or to lock the channel in place and prevent floodplain turnover. Available information suggests that confinement of about 50% or less (or a confinement ratio above about four) is needed for normal river function (Beechie et al., 2006; Fryirs et al., 2016).

Constriction and confinement in many Pacific Northwest Rivers have reduced floodplain rejuvenation, increased bank protection costs, increased flood levels, and eliminated the mature riparian forest needed for healthy river function; the current river corridor is not functioning well to support the flood and habitat management objectives.

Defining Target Corridor Widths

Qualities of a Functioning Pacific Northwest River Corridor

To define the relative virtues of different potential corridor widths, a qualitative description of the function of the target river corridor needed for it to meet the objectives identified above was developed, integrating the purposes of the different river corridor concepts and river processes described above. Applied to an example gravel bedded river where anthropogenic river management has reduced lateral mobility and metamorphosed the planform from a wandering to meandering condition, principal goals include restoration of a naturally-functioning floodplain rejuvenation regime, which includes both lateral migration to maintain flood flow conveyance and low elevation habitats and areas sheltered from lateral migration to support the growth of mature forest. Further, a goal is to establish an erodible corridor that minimizes channel impingement on the confining margin. A related goal, stated more in habitat terms, is a restoration of the historic wandering channel planform that is the primary mechanism to restore natural edge habitat, side channel and forested island habitat patches, and large wood inputs, which are necessary to form primary and high-quality pools. This will require an erodible corridor width equivalent to or greater than an appropriate meander belt width for the reach and local recruitment of key pieces of wood to the channel. A principal flood management goal is the presence of robust, low-maintenance flood and erosion protection infrastructure at the margin of the corridor, providing a reliable level of service in the face of dynamic floodwater and sediment inputs to the reach. To achieve this, erosion protection infrastructure should be set back from the margin of the channel to minimize the frequency and severity of attack, capable of withstanding occasional direct attacks from the river without requiring maintenance intervention and comprised of durable materials so that it will provide a high confidence long-term boundary to the erodible corridor. A mature forest buffer needs to be maintained around the higher turnover core of the river corridor.

Understanding Process Rates

A key control on the ability of the channel to conform to the vision outlined above is the width of the river corridor. Specific understanding of the rate of channel migration in the reach, rate of floodplain accretion, rate of channel aggradation, and hydraulic implications of various potential floodplain age and elevation distributions are needed to determine what river corridor widths are needed to achieve the vision outlined above. To outline a method for integrating understanding of these processes to evaluate relative benefits of typical corridor widths, we considered the Nooksack River, in Northwestern Washington (Figure 5), as an example system. The subject reach of the Nooksack River, described by NHC (2019), is a transition zone from a much steeper slope upstream (~0.2%) to a gentler slope downstream (<0.05%) where the bed material is shifting from cobble-and gravel- dominated upstream (D50 and D84 of about 48 mm and 79 mm, respectively in Lower Reach 4) to a gravel-dominated bed downstream (D50 and D84 of about 30 and 47 mm). Anderson et al. (2019) estimated a total volume of 330,000 ± 130,000 yd^3 of sediment accumulated in the three-mile-long subject reach between 2006 and 2013, which gives an annual rate of about 40,000 ± 15,000 $yd^3\ yr^{-1}$, or an average rate per mile of the channel of 13,300 ± 5,000 $yd^3\ mi^{-1}\ yr^{-1}$. The river also transports a very large volume of suspended sand and finer sediment through the subject reach estimated to be an average annual flux of 0.9 million tons (Anderson et al. 2019).

Floodplain accretion begins as soon as vegetation stabilizes a gravel bar that has been deposited by the river and occurs as fine sediment-laden floodwater spreads out from the channel, slows down and loses its capacity to maintain that material in suspension, causing it to settle to the ground. It needs to be quantified so that we can understand the expected elevation distribution of ground within the erodible corridor under different corridor width scenarios (that affect channel migration rates re-setting the low ground). Floodplain accretion rates on the Nooksack River were quantified by relating information about the channel migration history and detailed information about the elevation of the floodplain obtained from analysis of LiDAR topography data (Figure 4). Accretion rates start rapidly and decline through time, with about four to five feet of floodplain accretion in the first decade, about an additional 1.5 feet of accretion in the next decade, 0.5 feet of aggradation in the third decade, and 0.25 ft of aggradation over each of the fourth through 8th decades (Figure 5).

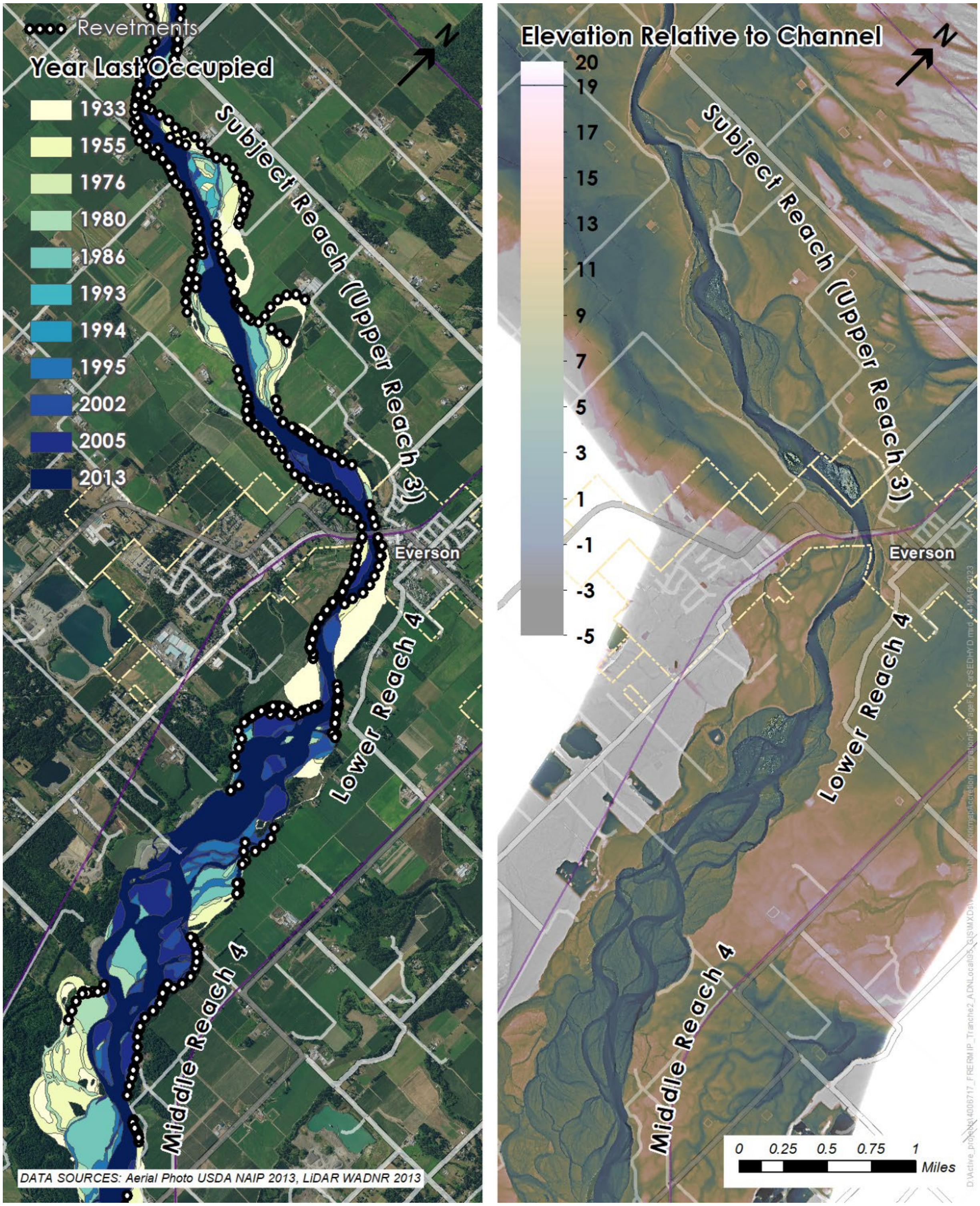

Figure 4: Historical Channel Migration Pattern and Relative Elevation Model of the example reach of the Nooksack River

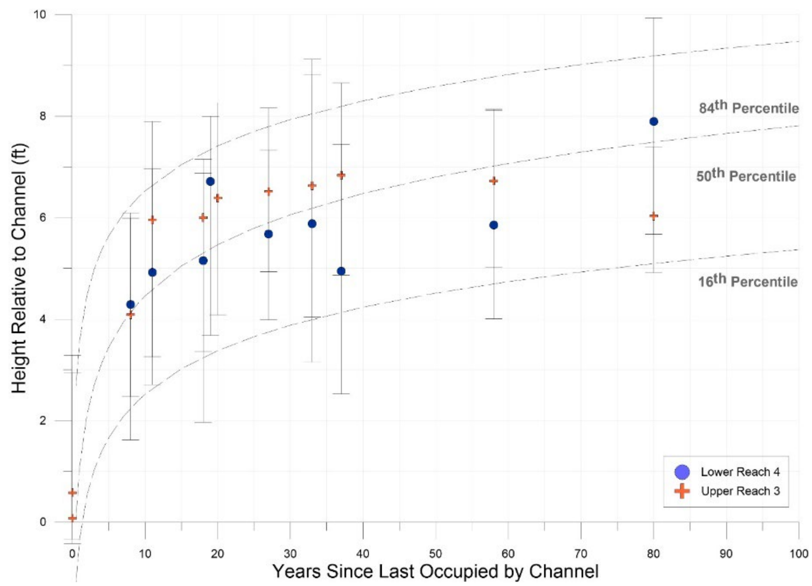

Figure 5: Pattern of floodplain accretion with increasing time since channel occupancy on the Nooksack River.

Gravel Aggradation: The gravel aggradation rate under existing conditions was described above, with a total volume of accumulating material of around 40,000 cubic yards per year (Anderson et al., 2019). If channel migration is occurring, this volume gets spread out over the years covering the whole area where the channel is allowed to move. We can calculate a *specific aggradation rate* (McLean et al., 2013), which is the rate of the vertical rise in the river bed, by dividing the volume of accumulating gravel over the area into which it may be distributed. Specific aggradation rates over the range of plausible erodible corridor widths are directly inversely proportional to the corridor width: they decline from about 7 ft over the next 50 years for a 500 ft corridor width, to 3.5 ft for the current 1,000 ft corridor width and to 1.75 ft for a 2,000 ft corridor. The discussion of gravel aggradation in the reach points out the necessity of some sort of gravel management to maintain flood profile stability through the reach and finite lifespan of local floodplain mapping that does not consider aggradation. In turn, this reveals an additional utility of maintaining a river corridor substantially wider than the bankfull channel: it gives the physical space needed for active gravel management to be completed outside of the active channel in a way that removes its primary damaging impacts and creates a significant positive opportunity to support valuable instream habitat and ESA-listed species; for example, by removing footprints designed to create side channel habitat features.

Floodplain Turnover: The rate and pattern of **floodplain turnover** define the expected age distribution of floodplain surfaces, giving information on the riparian forest age structure and, when paired with the assessment of floodplain accretion rates (above), the expected distribution of floodplain elevation within the corridor that provides conveyance for flood flows. To evaluate expected floodplain turnover rates, we use historical mapping of the channel margins (from Applied Geomorphology and DTM Consulting, 2019, Figure 5) to compute how the net erosion rate declines over increasing periods of elapsed time (Figure 6). This occurs because, after a long period of elapsed time, some floodplain has had time to form and then be re-eroded by the channel, while over very short periods, not enough time has elapsed to form a floodplain. The pattern of the decline in net erosion rates is then used to calculate the expected age distribution of the floodplain for various corridor widths

Assuming dynamic equilibrium in the channel width (that is, the channel is not getting appreciably wider or narrower through time), then we can derive the rate of floodplain formation and age directly from the age of eroded ground.[1] The actual width of ground eroded during an elapsed period is simply the average

[1] For a particular period elapsed t, we estimate the proportion of eroded ground older than period t (and deposited ground younger than period t) as the ratio of the average erosion rate for that period (R_t) to the short-term erosion rate (R_5) and the % of eroded ground younger than the period (E_t) is calculated as its inverse, $E_t = 1\text{-}R_t/R_s$. The

erosion rate for that period times its duration. The age distribution of ground within a given corridor width can finally be calculated by subtracting the channel width from the corridor width to define the floodplain width, finding the maximum age of expected surfaces within that floodplain based on the average floodplain turnover rate, and calculating the age distribution of the ground formed in that period of elapsed time (Figure 7).

Based on this analysis, a corridor width of greater than 1,750 ft would be needed to support the development of mature forest. The analysis described above assumes free migration within the erodible corridor; areas of the river with erodible corridor widths less than the characteristic meander amplitude may, depending on the configuration of the confining margins, either allow free migration of the channel within the erodible corridor or restrict much of the potential for lateral channel migration. If migration is restricted, then a binary age distribution, with only areas of young channel and areas of older, high, floodplain ground may develop within the river corridor.

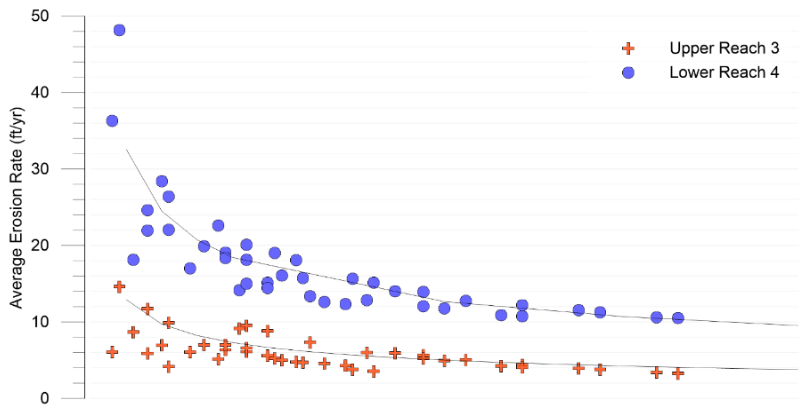

Figure 6: Average Nooksack River floodplain erosion rates calculated for each combination of available channel delineation periods.

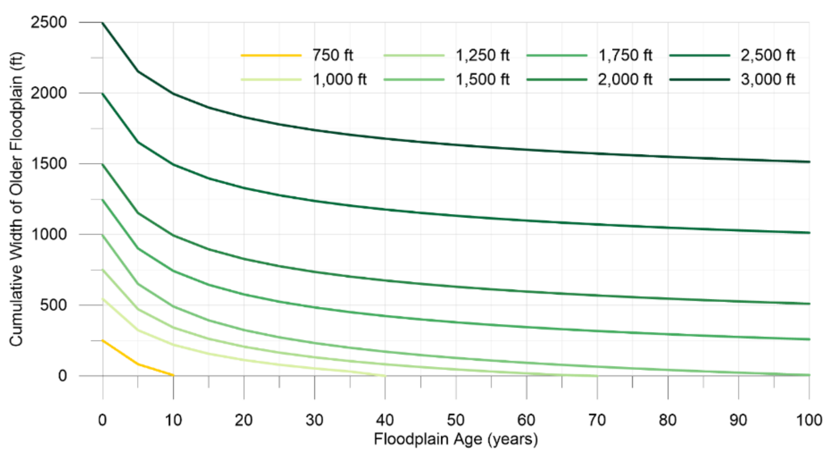

Figure 7: Predicted age distribution of floodplain within different erodible corridor width scenarios assuming a channel width of 500 ft and observed Nooksack River erosion rates.

proportion of eroded ground in each age class is then calculated as E_{t+1}-E_t. The age distribution of the deposited ground younger than t (D_t)is estimated to replicate the general population of ages predicted by the migration rate pattern as follows $D_t = \frac{E_t}{\sum_{i=s}^{t} E_i}$.

Flow Conveyance and Wetted Perimeter: Integrating results of the analysis of the floodplain turnover rate and floodplain accretion rates allows us to predict the influence of corridor width on flow conveyance. To do this, generalized cross sections representing the expected age distribution of floodplain ground were computed and single-cross section normal depth calculations were completed for 1.01, 2, 5, and 100 yr recurrence interval flows for the main channel (during the 100-year flood, substantial flow is routed through floodways across the floodplain outside of the channel corridor). Flow conveyance functions for different corridors were calculated by computing the difference in the water surface elevation between the 1.01 flow and each of the larger flood magnitudes. For the 100 year flow, this difference is 6 ft for the most constricted scenario (260 ft, representing current constrictions, and declines to 5 ft for a floodplain elevation scenario for a 750 ft corridor with restricted lateral migration assumed. Removal of restriction on lateral migration drops the impact to 3.5 ft, and it continues to decline to 3 ft at a corridor width of 1,500 ft (Figure 8). Little change in the water surface difference occurs above a corridor width of 1,500 ft because very little flow is conveyed through the higher elevation and hydraulically inefficient floodplain added above this corridor width.

The relationship between river corridor width and wetted perimeter of the channel, which is an indicator of available habitat area, was also calculated for the 1.01, 2, and 5 yr recurrence interval flows (Figure 9). This shows increases in the wetted perimeter for any given flow up to a 1,500 ft corridor width but no increases above that value.

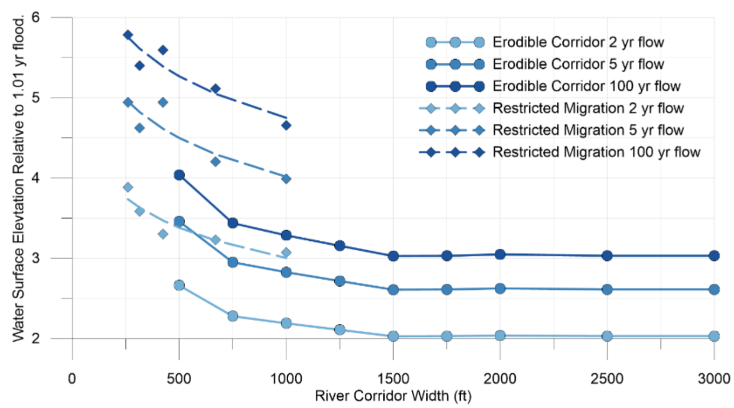

Figure 8: Impact of corridor width and character on the difference in flood flow stage between the 1.01 yr recurrence interval flow and main channel 2, 5, and 100 yr flows. Note that the 'restricted migration' results are considered much more likely to occur than the 'erodible corridor' for corridor widths of 1000 feet or less.

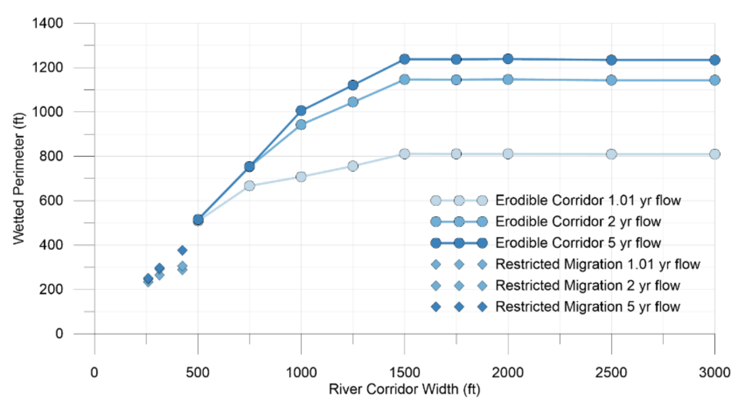

Figure 9: Relationship between river corridor width and wetted perimeter of the channel.

The marginal increase in value of increasing corridor withs Following the process rate quantification exercise described above, the marginal increase in value of increasing corridor withs was calculated for the identified suite of flood management and habitat indicator objectives for the river. For each metric, the full function was defined as a value meeting the management goal for that attribute, and the proportion of full function (which can be >100%) was calculated based on deviation from that objective. Flood management indicators included the specific aggradation rate, bank protection maintenance frequency, and flood flow conveyance. Habitat indicators included natural bankline at the edge of the main channel, edge habitat area, connected channel migration area, forest islands, side channels, and riparian forest area and age. Results of this assessment are summarized in Figure 10. This shows that the value of both flood protection functions and habitat increase rapidly with increasing river corridor widths between 500 ft and about 2,000 ft and that functional gains above 2,000 ft approach an asymptote of maximum function at the width of the valley bottom. Average and median full function for habitat indicators is achieved at a width of about 1,500 to 2,000 ft. The indicator requiring the largest corridor width is the restoration of the whole historic migration area plus a 300 ft buffer, which requires a 2,600 ft corridor. The median value for full function in flood protection values is 1,600 ft. The 1,500 to 2,500 ft corridor width pointed to by other indicators only provides 20 to 35% function for managing the specific aggradation rate, which suggests measures in addition to corridor management may be required to protect that value; maintaining a corridor width substantially wider than the bankfull channel would allow implementation of strategies for active gravel management that positively impact habitat for ESA listed species.

Illustrations of expected conditions within corridors of varying width are shown in Figure 11.

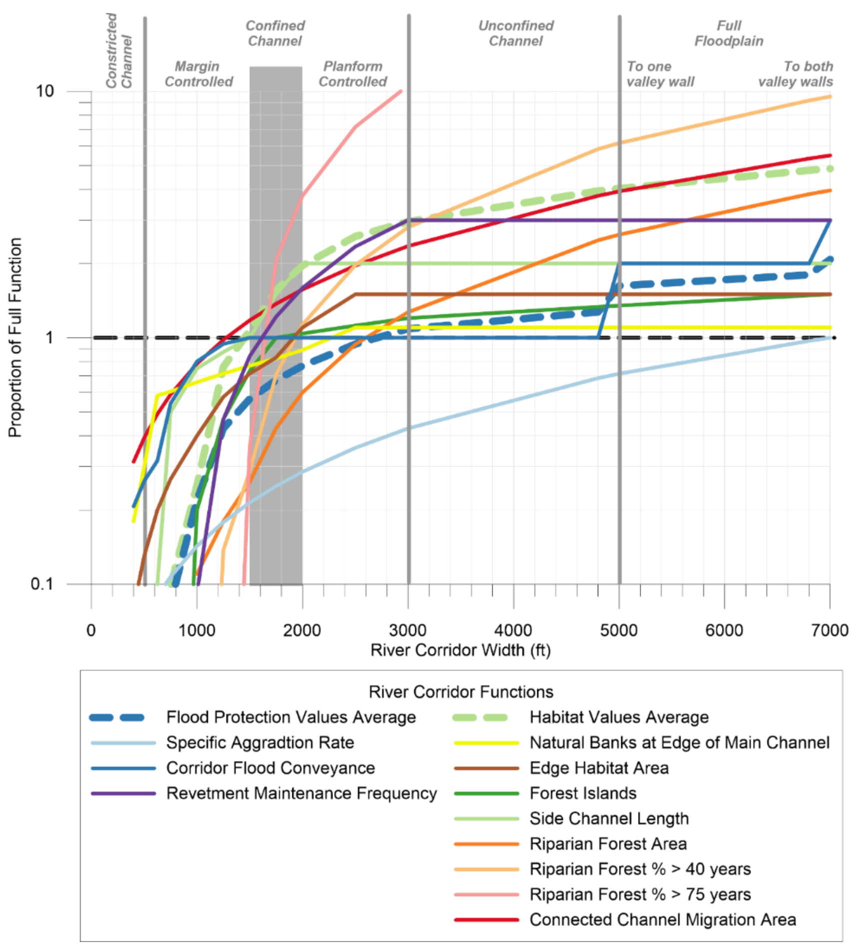

Figure 10: Estimated proportion of full function for flood protection and habitat functions with varying river corridor width.

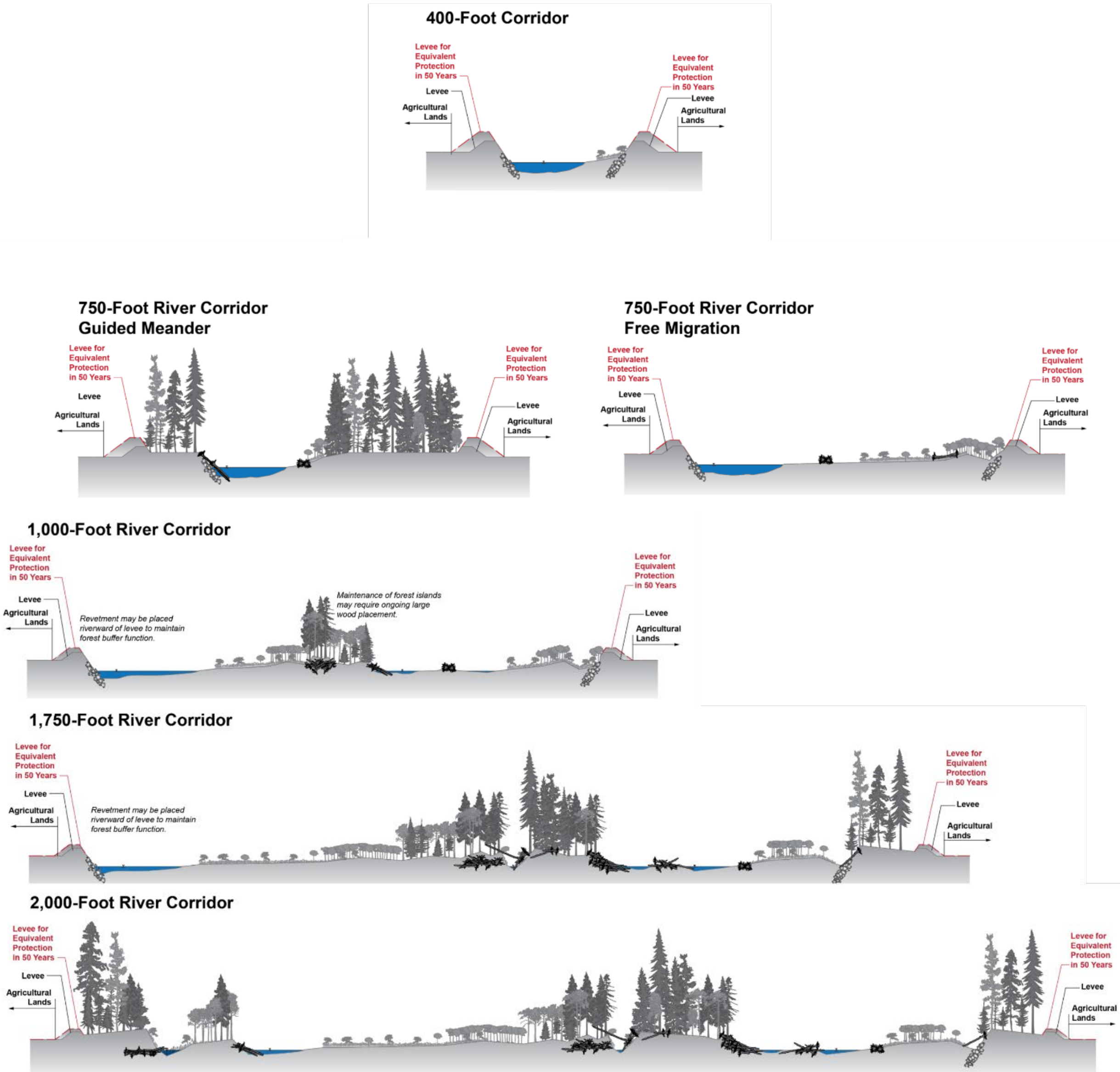

Figure 11: Illustrations of expected character for river corridors with increasing width. Levee height for equivalent protection in 50 years indicates the height required to accommodate expected aggradation in each scenario and does not include any factor considering expected changes to flood flow due to climate change. Note the Guided Meander scenario is considered more likely to occur than the Free Migration scenario.

Conclusion

For the example reach of the Nooksack River in northwest Washington State, we find major stepwise gains for habitat and flood protection values occur at the transition from constricted- to confined conditions, additional rapid gains in habitat and flood function through the range of river corridor widths expected to correlate to margin-controlled confinement, followed by asymptotically-reducing rate of gain in function for river corridor widths substantially exceeding the threshold for planform controlled conditions. This pattern of increasing function implies that major improvements in flood and habitat function values would be unlocked by a marginal increase in the river corridor width compared to the existing condition; these large gains occur at widths (1,500 to 2,500 ft) that are much narrower than the entire 7,000 to 15,000 ft wide valley bottom but wider than the current 300 to 1,000 ft functional river corridor. The implication is that the magnitude of change needed to both improve flood management goals and achieve a healthy river may be socially acceptable and represents a worthwhile medium to long-range planning goal. We expect the analytical template for the example reach of the Nooksack River shared here to be directly applicable to other (historically) laterally mobile gravel bedded rivers where the same suite of processes govern, although some adaptation may be required to fit local management objectives. Further, similar exercises following a more generic template, evaluating river corridor value as a function of expected floodplain age and elevation distributions, may serve a valuable function in long-term landuse and river restoration planning activities in diverse environments.

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