Hydrodynamic Modeling in the Yolo Bypass to Support Salmonid Habitat Restoration

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Significant modifications have been made to the historic floodplains of California's Central Valley for water supply and flood damage reduction purposes. The resulting losses of rearing habitat, migration corridors, and food web production for fish have significantly hindered native fish species that rely on floodplain habitat during part or all of their life history. To support the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project, a collaboration between the California Department of Water Resources and US Bureau of Reclamation, previous modeling efforts were improved with the development of a calibrated TUFLOW model of the Yolo Bypass and vicinity. The TUFLOW model analyzes multiple alternatives aimed at increasing seasonal floodplain inundation in the lower Sacramento River Basin and improving fish passage throughout the Yolo Bypass. The best available topographic and hydrologic information was used in preparing the model. The model was calibrated to a range of flow conditions representative of seasonal floodplain inundation as well as flood conditions. Hydrodynamic model outputs are being used to derive spatially explicit annual inundation footprints. These footprints are then used to assess the effects of increased frequency, depth, and duration of floodplain inundation on agriculture, fish, and waterbirds. The TUFLOW model will be an important planning tool as managers continue to try and find sustainable solutions for agriculture, fish, recreation, and terrestrial species in the Yolo Bypass.

Keywords: Yolo Bypass, Flood Control, Fish Passage, Fish Habitat, Ecology, Hydraulics

Poster cluster: Yolo Bypass: Connecting Science, Policy and Management

Uncharted Territory: Paving the Road for Future Large-Scale Restoration Projects

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Modern water delivery and flood control systems have virtually eliminated access to the vast majority of historic Central Valley floodplains. These floodplains once served as vital rearing habitat for native fish species. The Yolo Bypass presents an opportunity to provide juvenile salmonids with the rearing habitat critical to their growth and survival. Initially constructed as a flood control measure, the Bypass is not currently designed to optimize fish passage or juvenile rearing habitat requirements. The 2009 NMFS Biological Opinion on the Long-term Operations of the CVP and SWP prescribed the increase of seasonal floodplain habitat and improved fish passage in the Yolo Bypass. Currently, the Department of Water Resources and US Bureau of Reclamation are working to develop alternatives to comply with the Biological Opinion and minimize impacts to existing land uses in the Yolo Bypass. DWR and USBR are incorporating results from past and recent monitoring to help formulate and evaluate alternatives. Preliminary hydrologic and biological modeling results have helped form design and operational criteria required for fish passage and inundation structures. Developing design and operational criteria for salmonids and sturgeon in a flood bypass is a critical step towards the formation of a set of potential alternatives to be further examined as part of the EIR/EIS process. Fish passage structures on streams and rivers have been heavily studied on the west coast, but fish passage through a flood bypass coupled with increased access to rearing habitat of this scale has never been attempted. Every milestone reached in the development of this project will help pave the way for future large-scale floodplain restoration efforts.

Keywords: Yolo Bypass, Fremont Weir, fish passage, inundation, floodplain, salmon, sturgeon

Poster cluster: Yolo Bypass: Connecting Science, Policy and Management

Bloom or Bust: Fall Fish Food Trends in the Yolo Bypass

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The Yolo Bypass is a large, 59,000 acre engineered floodplain that, when inundated, becomes an important source of food for native fish species such as Sacramento Splittail and juvenile Chinook Salmon. This warm shallow habitat has long been valued by floodplain-adapted native fish, which rely on this environment for spawning, rearing, and foraging. Seasonal phytoplankton blooms, usually seen in winter and spring when inundation occurs, are important for the survival of many larval and juvenile fish species. Recent evidence has shown similar benefits can also be found during non-inundation periods, when agricultural discharge creates increased flows through the bypass. The increased availability of phytoplankton biomass has been linked to positive bottom up effect on the entire Delta ecosystem, leading to an increase in zooplankton. To investigate the role of this phytoplankton on zooplankton populations in the critical fall period, we examined zooplankton trends using data from the Yolo Bypass Fish Monitoring Program. A key motivator for this study is evidence from 2011 and 2012 that a phytoplankton bloom in the lower Sacramento River was seeded by contributions from the Yolo Bypass. Leading up to these fall blooms, increased flow pulses from the drainage of rice fields acted to transport high residence-time water out of the perennially wetted toe drain of the bypass into the delta. This transport has direct positive implications for the zooplankton and pelagic fish community downstream. Initial study results from 2012 and 2013 have shown that the phytoplankton species composition during the fall flow pulse is dominated by higher nutritional quality diatoms, which are a primary food for copepods and cladocerans. The benefit of these zooplankton species is significant as they comprise a substantial portion of the diet for larval and post-larval native fishes, including Delta smelt.

Keywords: Food webs, Floodplain, zooplankton, phytoplankton blooms, rice drainage, Yolo bypass

Poster cluster: Yolo Bypass: Connecting Science, Policy and Management

Conserving Terrestrial Species on the Yolo Bypass Floodplain

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The Yolo Bypass Fisheries Enhancement Conservation Measure (CM2) of the BDCP will increase the frequency, magnitude, and duration of floodplain inundation to benefit several native fish species. Increased floodplain inundation will periodically affect terrestrial species habitat in the bypass, including that of six vertebrate species covered by the BDCP: tricolored blackbird, Swainson's hawk, western burrowing owl, white-tailed kite, greater sandhill crane, and giant garter snake. These species occupy and utilize a combination of different habitat types (managed wetlands, cultivated lands, tidal and nontidal wetlands, and grasslands), requiring careful and strategic planning to develop a comprehensive conservation strategy that addresses the needs of both aquatic and terrestrial species, while also considering other land uses, such as agriculture and flood control. Yolo Bypass improvements presents a unique opportunity for local and regional landowners to partner on conservation actions for a multitude of species, while providing for the long-term protection of important cultural, economic, and biological resources. The conservation strategy for species occupying the Yolo Bypass was developed by a team of species, habitat, and flood control experts, including consultant and agency staff, and focuses on creating and protecting a mosaic of land types including large patches of nontidal and tidal wetland, cultivated land (primarily rice and pasture), and grassland. Lands created, restored, or protected within the Yolo Bypass will be enhanced and managed to benefit native species including BDCP covered species, waterfowl, and shorebirds. This poster will present the modeling and GIS approach used to craft the conservation strategy and effects analysis for the Yolo Bypass as well as a summary of the natural community and species-specific conservation strategies, and how they can be implemented in a way that is beneficial to land users and native species.

Keywords: Yolo Bypass, Terrestrial Conservation, Floodplain, BDCP

Poster cluster: Yolo Bypass: Connecting Science, Policy and Management

Presence of Juvenile Fishes in Yolo Bypass during Dry Years

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The Yolo Bypass is a 59,000 acre engineered floodplain that has been the focus of many ecological studies. Flooding in the Yolo Bypass occurs during years of heavy rainfall primarily when the Sacramento River overtops the Fremont and Sacramento Weirs. These flood events in the Bypass are able to convey up to 80% of the Sacramento River basin outflow, and it is now widely accepted that this engineered floodplain provides valuable habitat for many native fishes, especially Sacramento splittail and juvenile Chinook salmon. High productivity in the shallow, warm flood waters provide juvenile fish with abundant food sources, increasing their growth rates. However, the toe drain of the bypass, a perennial tidal channel that borders the east side, may be a perennial source of productivity, drawing juvenile fish up from the delta in response to high resource levels. The toe drain's primary source of water in dry years is irrigation water drained from agricultural fields, and it subsequently connects downstream with the Cache Slough Complex. We examined how the toe drain of the bypass may affect the presence or absence of juvenile fishes in non-flood years (years in which the Fremont Weir did not overtop). Even during extreme dry conditions, like the past water year (2013-2014), we observed a substantial number of juvenile fish, particularly Chinook salmon, in the Yolo Bypass toe drain. Documenting potential benefits of the Yolo Bypass to species of conservation concern during years without flooding is critical to understanding the role this important waterway plays in the ecology of the delta during all types of inflow scenarios.

Keywords: Chinook salmon, Yolo Bypass, non-flooded years, conservation

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Yolo Bypass Fish Monitoring Program

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The Yolo Bypass is the primary floodplain of the Sacramento Valley. The Yolo Bypass Fish Monitoring Program has conducted studies and fisheries monitoring in the bypass continuously since 1997. This monitoring, primarily centered on the perennially wetted toe drain of the bypass, includes the operation of a rotary screw trap and fyke trap, biweekly beach seine surveys, zooplankton and drift invertebrate sampling, and water quality monitoring. Results from this monitoring have revealed that the Yolo Bypass is a major contributor to year class strength of Sacramento Splittail, a key migration corridor for adult fish of salmon and sturgeon, one of most important regional rearing areas for juvenile Chinook Salmon, a net source of phytoplankton to the food web of the San Francisco Estuary, and supports an endemic, floodplain dependent invertebrate. In particular, portions of the Yolo Bypass have been identified as key habitat for Delta Smelt and an important source of food for pelagic organisms, whose number have declined in recent years. The Yolo Bypass has been identified as a key area for future habitat restoration, and as such the Yolo Bypass Fish Monitoring Program provides for crucial baseline data and, moving forward, an important tool by which to gauge the success of any putative conservation measures.

Keywords: Yolo Bypass, Floodplain, RST, FYKE, Beach Seine, Lower Trophic

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Utility of Passive Integrated Transponder (PIT) technology to examine juvenile salmon habitat preference on an agricultural floodplain

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The Yolo Bypass is an extensive 59,000 acre floodplain that is managed for farming, wildlife habitat, and flood control. When the Bypass floods (approximately 70% of years), it has been shown to provide quality habitat for juvenile salmon, enhancing growth and survival. Knaggs Ranch is an agricultural parcel within the Yolo Bypass that farmed for rice during the growing season, but is inundated along with other parts of the bypass during high water periods. As part of the larger 2013 Knaggs Ranch Experimental Floodplain project, we explored the feasibility of using passive integrated transponder (PIT) technology to examine individually-based growth, survival and habitat use across three basic agricultural land treatments: fallow, disked and rice stubble.

84 juvenile hatchery salmon 69 mm - 84 mm (FL) were implanted with either 8 mm or 12 mm PIT tags, and divided equally between experimental (fallow + disced + stubble) and control (disced only) enclosures along with non-tagged fish (including surgically treated fish). Approximately 2 million detections were recorded during the 2-week experimental period. Survival was high (~98%) and identical for both tag sizes. However, detectability of 8 mm tags was much lower than for 12 mm tags. Growth rate was very high, averaging over 1.1 mm per day for all habitats and tag sizes, and tagged fish & non-tagged fish alike. Detection patterns suggest that fish did not show a distinct preference for a specific habitat. Overall results indicate that PIT technology can be a useful tool to examine juvenile salmon movement in the open, shallow and non-linear (non-riverine) floodplain environment. However, the management of large resulting datasets and the limited detectability of the smaller tags are important considerations that should be taken into account during study planning.

Keywords: Yolo Bypass, Floodplain, Juvenile salmon, Agriculture, PIT tag, Habitat

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Discovering the Flyway at the Yolo Bypass Wildlife Area

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Yolo Basin Foundation is training the next generation of Delta scientists and conservationists. The *Discover the Flyway* program for schools is a partnership between Yolo Basin Foundation and the CA Department of Fish and Wildlife at the 16,800-acre Yolo Bypass Wildlife Area. Over 50,000 K-12 students have participated in the *Discover the Flyway* program since its inception in 1997. The students come from more than 100 schools in Sacramento, Yolo, Solano, Placer and El Dorado Counties. This unique program provides students with a day of exciting hands-on, inquiry-based activities that are tied to the State Science and Social Studies Framework for each grade level. Students are able to see first hand how agriculture, flood protection and wetlands co-exist at the Wildlife Area, all within sight of the Sacramento skyline. For many of the students the *Discover the Flyway* field trip is their first opportunity to experience the excitement of seeing tens of thousands of migratory geese, ducks and swans, as well as otters and beavers. In order to enhance the grade-level curriculum needs of teachers, Yolo Basin Foundation provides them with a one-day workshop where they learn pre and post activities to supplement their *Discover the Flyway* field trip. Through fundraising in the private sector Yolo Basin Foundation is able to hire expert staff to train volunteers and teachers and provide grants to cover bus transportation costs for class visits from low-income neighborhood schools. Student to staff or volunteer ratios are 8:1 so that each child has a high quality experience. During the 2013-14 school year, 3,600 students and 1,000 parent chaperones spent an educational and memorable day at the Yolo Bypass Wildlife Area.

Keywords: Yolo Bypass students flood agriculture wetlands school partnership wildlife migratory

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Resolving Stakeholder Concerns in the Name of Restoration: Case Study of the Yolo Bypass

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The Bay Delta Conservation Plans (BDCP) Conservation Measure 2 (CM2) is expected to contribute significantly to the achievement of the BDCP Biological Goals and Objectives for covered fish species including salmonids, Sacramento splittail, and sturgeon. The goal of CM2 is to improve fish passage through the Bypass and past Fremont Weir through modifications to the structure and increase the extent, frequency, depth, and duration of floodplain inundation to increase fish habitat quantity and quality. The scientific literature supports the assumption that implementation of CM2 will provide significant benefits for covered fish species including increased survival of juvenile salmonids and juvenile and adult sturgeon and increased splittail abundance. However, achieving these benefits will require accommodation by various stakeholders, including Wildlife Area land managers, local and regional agencies, and agriculture and flood control agencies. There will also be impacts to some wildlife species, including several BDCP covered species. Extensive coordination between various stakeholders is required to balance the needs of existing land users and the restoration and enhancement of floodplain habitat in Yolo Bypass. This poster outlines major stakeholder concerns and how the BDCP is proposing to address them, with emphasis on finding a sustainable balance between the biological benefit BDCP must achieve and the consequences of CM2 implementation on cultural, recreation, biological, and agricultural resources. The poster also highlights the science supporting the BDCP Biological Goals and Objectives for covered fish species, and the interconnectedness of the various regulatory and planning actions that all converge in Yolo Bypass.

Keywords: Yolo Bypass, Stakeholders, BDCP, Conservation Measure 2, Biological Goals Objectives

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A New Method for Quantifying Flood Plain Habitat and Function

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Floodplains provide a variety of beneficial functions, but floodplain managers lack tools to systematically quantify these benefits. We have developed a new method and metric for quantifying the basic inundation characteristics that determine the value of a floodplain for a variety of functions and species (Matella and Jagt, 2013). The expected annual habitat (EAH) method relies on standard flood management planning tools and data to conduct (1) statistical analysis of the hydrologic record and (2) spatial analysis of hydraulic modeling results. Targeted queries of the hydrologic record using HEC-EFM determine how frequently an area is inundated for a specified duration and time and inform the creation of area-duration-frequency (ADF) curves for a river segment and floodplain. We combined hydraulic model output with topographic data to create flow versus inundated area curves or flow versus habitat curves where a habitat suitability curve incorporating timing, depth, or velocity is available. The primary innovation of the EAH method is combining inundated area with flow frequency to generate ADF curves that characterize areas of frequently inundated floodplain. The area under an ADF curve can be distilled to one number that represents the expected annual habitat for any species including agricultural crops.

Keywords: floodplain, habitat, hydrology, restoration planning

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Recent Applications of the Estimated Annual Habitat method to measure, design, and evaluate floodplain habitat

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Until recently, the lack of replicable methods for measuring floodplain habitat has limited the ability of managers to evaluate historic changes in the quantity of floodplain habitat or plan and design floodplain restoration projects. The development of hydraulic models and high resolution topographic data developed as part of the Central Valley Flood Protection Plan has facilitated the development of the expected annual habitat (EAH) method (Matella and Jagt, 2013), which in turn has enabled managers to plan and evaluate a broad range of floodplain restoration projects.

The EAH method can quantify the floodplain habitat effects of any project that either modifies hydrology or floodway geometry. Aside from the data and hydraulic modeling issues that arise in any flood management study, the calculation of EAH is transparent and replicable. Calculation of inundated area and frequency of inundation is based solely on stage discharge relationships and standard frequency analysis statistics. EAH is therefore a replicable, scientific method that is not subject to distortions associated with weighting factors or professional opinion.

American Rivers, a national river conservation organization, has worked with scientists, engineers, and planners to develop the EAH for a range of applications across the Central Valley. These include use of the EAH to measure the existing area of floodplain habitat in the Central Valley, estimate the amount of floodplain habitat necessary to double anadromous fish populations, quantify the floodplain habitat characteristics of the Southport levee set-back project in West Sacramento, evaluate floodplain management conflicts in the Yolo bypass, plan floodplain and flow restoration on the Stanislaus River, measure the floodplain benefits of levee set-back and flow augmentation scenarios on the lower San Joaquin, and predict the agro-economic impacts of removing levees on the lower San Joaquin River.

Keywords: floodplain habitat, floodplain, restoration, hydrology, hydraulic model

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Flood Management Planning – Drivers for Change in the Yolo Bypass

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The 2012 Central Valley Flood Protection Plan (CVFPP) focused on improving flood risk management for areas protected by the facilities of the State Plan of Flood Control (SPFC).

The Sacramento River Basin-Wide Feasibility Study (BWFS) is currently being prepared as part of the 2017 CVFPP Update. The BWFS focuses on evaluating system-scale improvements (bypasses) that reduce flood risk and provide multiple benefits.

The *systemwide approach to* flood risk reduction looks to provide:

- Reduction in the occurrence of flooding
- Reduction in damages when flooding does occur
- Increased flexibility of the system to accommodate increased flows in the future due to uncertainty in hydrologic conditions such as climate change
- Opportunities to achieve the CVFPP supporting goals of improving O&M, promoting ecosystem functions, and promoting multi-benefit projects
- A forum for coordinating with other planning efforts to leverage ongoing work efforts and identify synergistic actions and opportunities for alignment

The Yolo Bypass has significant potential to attenuate and convey large system flows from the entire Sacramento River basin and provide meaningful ecosystem restoration opportunities. The CVFPP poster will focus on describing the science, tools, and methods being applied to evaluate the flood risk drivers and benefits associated with potential improvements to the Yolo Bypass.

Keywords: CVFPP Flood Management Planning Climate Change Basin-wide Feasibility Study multi-benefit

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Central Valley Flood System Conservation Strategy

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Central Valley Flood System Conservation Strategy

The Conservation Strategy is an integral part of the Central Valley Flood Protection Plan (CVFPP), an integrated approach to flood management that provides public safety, environmental stewardship, and economic stability. While improving flood risk management is the primary goal of the CVFPP, four secondary goals have been identified for this program. These include: improving operations and maintenance; promoting ecosystem functions; improving institutional support, and promoting multi-benefit projects. The Conservation Strategy supports these goals and provides more specific ecological goals including: improving and enhancing dynamic hydrologic and geomorphic processes; increasing and improving the quantity, diversity, quality, and connectivity of riverine aquatic and floodplain habitats; contributing to the recovery and sustainability of native species populations and overall biotic community diversity; and reducing stressors related to the development, operation, and maintenance of the flood management system that negatively affect at-risk species. The Conservation Strategy includes: improved science and planning information; a regional permitting approach; an improved approach to vegetation management; and ecological targets and measurable objectives. Implementation of the Conservation Strategy will be through multiple-benefit flood improvement projects, integrated planning, coordination with other conservation planning efforts, and agricultural stewardship. The Conservation Strategy builds upon the Conservation Framework that was adopted by the Central Valley Flood Protection Board as part of the 2012 CVFPP. A draft Conservation Strategy will be completed in December 2014 and integrated into the 2017 update of the CVFPP.

Keywords: conservation, flood management, integrative projects, planning, multi-benefit projects

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Lower Putah Creek: Restoration Design within a Highly Managed Yolo Bypass

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Habitat and fisheries conditions in the reach of Lower Putah Creek within the Yolo Bypass have been shaped by agricultural activities, flood control, vegetation management practices, and construction and operation of the Solano Water Project. Hydrology and geomorphology in this reach continues to be dominated by its use as a 'reservoir' for irrigation of neighboring agricultural lands, and for flooding of the seasonal (managed) wetlands on the YBWA. The creek is seasonally dammed (from April 1 to December 1 each year).

The Lower Putah Creek Restoration Project must be designed within the context of maintaining current water management practices and legal mandates, flood conveyance capacity, Yolo Bypass inundation, and public uses including agricultural leases, managed wetlands, and hunting on the YBWA. Adequate conditions for passage of adult salmon must be achieved in a new stream channel which will travel over a distance of 4 to 5 miles with a fall in elevation of only 7 feet. The restoration will include creation of a new (fish friendly) diversion structure and new stream channel, connecting reaches of Putah Creek upstream of the Bypass, through previously restored tidal habitat (that will be enhanced as an element of the project), to the Toe Drain. This feature will allow adult salmon to enter the stream at least one month earlier than under current conditions. The new channel will bypass the last 2.3 miles of the existing Lower Putah Creek channel (a constructed irrigation ditch). The new channel design will include a series of shallow, seasonal wetlands to provide high quality rearing habitat.

Not unlike other restoration efforts planned in the Delta, implementation of this action presents considerable challenges related to reconciling the goals of restoration of habitats and ecological functions that support native species with the realities of working within a highly managed Delta system.

Keywords: Yolo Bypass, Putah Creek, fish passage, restoration, floodplain, salmonids

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Permanent Wetlands Act as Polishing Ponds to Remove MeHg from Managed Freshwater Seasonal Wetland Tailwater in the Yolo Bypass Wildlife Area

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Managed freshwater seasonal wetlands often show patterns of elevated monomethylmercury (MMHg) concentrations and fluxes relative to other habitat types. Proposals to increase total acreage of seasonal wetlands in the Sacramento-San Joaquin Delta through restoration efforts may have unintended consequences of increasing MMHg in water, sediment, and biota. In this study, we investigated the potential for water quality improvement using permanent wetlands as treatment ponds. We utilized two existing permanent wetlands in the Yolo Bypass Wildlife Area in addition to constructing nine replicate large scale experimental permanent wetlands which allowed for controlled studies of mercury cycling. Weekly mass balance models for both the existing and experimental permanent wetlands were calculated. These models yield the net mass reductions of MeHg and relative importance of internal processes such as photodegradation, sediment water exchange, and particulate settling within the wetlands. Results indicate the permanent wetlands act as treatment ponds reducing levels of MeHg in drain water from managed seasonal wetlands. This information is useful to wetland restoration efforts and wetland managers as a way to mitigate MeHg loads from managed wetlands.

Keywords: Mercury cycling; Methylmercury; Wetlands; Seasonal Wetlands

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