Appendix 18. Paleoecological Context and Characterization of Risks Associated with Potential Interbasin Biota Transfers

Of those biota of concern identified by Reclamation and stakeholders on the Technical Team, the fishes and aquatic invertebrates provided a relatively data-rich source of existing information georeferenced locations for records of occurrence (e.g., FishBase, http://www.fishbase.org/ and similar data sources). Owing to the long-standing academic interest, historic and ongoing efforts by resource management agencies, and past interbasin water diversion studies, the current analysis benefitted from a diffuse collection of life history and distribution accounts (see Appendix 3A, Appendix 6, and Appendix 7) upon which the analysis of risk could be implemented quantitatively through a categorical and spatial analysis, which is summarized in Section 4 as part of the narrative analysis of risks associated with potential transfers of fishes collateral to an interbasin water diversion between Missouri River (exporting source area) and Red River (importing receiving area). For the fishes, as well as other biota of concern, placing our current "snapshot" of species distributions in ecological context requires a background in the dynamic character of biogeography, and past climate regimes and the distribution of fishes in the northern Great Plains illustrates the temporal considerations of the risk analysis.

Paleoecology of North American fishes: An illustration of changing species distributions through time. Numerous authors (see Mayden 1992) have considered various aspects of the biogeography of the fishes of North America, with distribution histories of North American fishes considered in detail by Burr and Mayden (1992), which serves as our primary source for this characterization. In early biogeographical analysis of fishes of North America, Gilbert (1976) suggested the Cyprinidae, Percidae, Catostomidae, Esocidae, and Umbridae came to North America from Eurasia; the Poeciliidae are of Central American derivation; the Cichlidae, Characidae, and Pimelodidae have reached the Nearctic region through relatively recent dispersals northward; the archaic Acipenseridae, Polyodontidae, Lepisosteidae, and Amiidae have a mixed origin; and the remainder of the families are of marine origin. Only eight families—Hiodontiade, Ictaluridae, Percopsidae, Aphredoderidae, Amblyopsidae, Coodeidae, Centrarchidae, and Elassomatidae—originated in North America, according to Gilbert's work of over 35 years ago. During the intervening years, alternative hypotheses (see, e.g., Patterson, 1981 and others cited in Burr and Mayden 1992) have been developed and the origins of North American icthyofauna remain a topic of keen research interest.

North Dakota, Minnesota, Manitoba, and Ontario occur in the Nearctic which includes many hydrological units and ecoregions (see Appendix 1 and Appendix 2, respectively), and biogeographic provinces throughout the continent (Figure 1 after Burr and Mayden 1992). Following Burr and Mayden (1992), a relatively coarse-grained mapping of fish fauna provinces suggests that the origin of fishes in the areas of concern is likely easily confounded, if resolution at a 2-digit HUC perspective is desired. Although survey works completed over the past 15 years support a higher resolution analysis (see Petreka and Koel 1996; Koel 1997), faunistic differences between HUC09 and HUC10 are incompletely documented in the current biogeographic literature. Hence, the fishes identified by Reclamation and members of the Technical Team generally represented species whose native distribution (or current distribution, if the species was already considered "invasive") did not reach Red River basin surface waters and sufficiently characterized them as species potentially of concern for being transfers from Missouri River source waters to Red River, if water diversion between watersheds occurred.

At the spatial scale of the faunal province, the Hudson Bay Province and Mississippi River Province were most pertinent to our analysis, although provinces immediately adjacent to these coarse-scaled regions (coarse-scaled relative to a 2- or 4-digit HUC) should not be completely dismissed as potential sources. For example, the Yukon-Mackenzie Province and Hudson Bay Province (see Figure 5 for location) display a common species composition, characterized by freshwater fishes that have apparently invaded from the Mississippi Province (or other more southern provinces). Hudson Bay Province includes all watersheds of Hudson and Ungava Bays in much of Canada and in the north-central US (see Crossman and McAllister 1986), with the species' composition displaying strong affinities with both Mississippi and Great Lakes Provinces. No species are endemic to the Hudson Bay Province, and many fish species occur only at the southern edges of the province. Burr and Mayden (1992) note of the Hudson Bay Province:

> "As a result of Pleistocene glaciation the [fish] fauna has occupied the province for less than 14,000 years. The distribution patterns of fishes reflect mainly the postglacial reinvasion of these drainages with dispersal through glacial lakes and rivers, shifting, watersheds, and coastal waters (Crossman and McAllister, 1986)."

From a faunistics perspective, Missouri River drainage (HUC10) is part of the Mississippi Province which consists of areas of the US and Canada currently drained by the Mississippi-Missouri-Ohio Rivers. In North America the Mississippi Province presents the richest ichthyofauna, including families thought to have phylogenetic origins in North America.

Mississippi Province has served as a refuge during glaciation and has been a source area for fishes characteristic of past faunal assemblages. Burr and Mayden (1992) have gone as far to state that the

> "Mississippi fauna is clearly the "mother" fauna of North America and much of the diversity of surrounding provinces can be accounted for by spillover from this cradle of temperate freshwater fish diversity."

From the perspective of a paleoecologist, late Pleistocene and early Holcene were dynamic landscapes where current day boundaries between biogeographic provinces and their constituent watersheds differed, in some instances markedly differed, from our present-day snapshots of these systems, including landscape features as the continental divide for waters flowing to Hudson Bay and waters flowing to the Gulf of Mexico (see Teller and Clayton 1983; Figure 2). Results of geological and paleoecological studies also suggest that not only were glacial lakes such as Lake Agassiz interconnected with surface waters of Mississippi Province but several connections with Great Lakes-St. Lawrence Province also existed (Figure 3), yielding a mixing of fish fauna (and other aquatic biota) across current boundaries, especially during periods of glacial retreat. As a consequence, the ichthyofaunas of these regions are similar, particularly when fishes of the northern part of the Mississippi Province are compared to the Hudson Bay and Great Lakes-St. Lawrence fish fauna (see Burr and Mayden 1992). The areas of concern in the Red River and adjacent areas of the Great Lakes-St. Lawrence Province were variously covered with ice of the Wisconsin Age until about 15,000 years ago (see Teller and Clayton 1983; Underhill 1986), with surface waters of the Mississippi Province serving as refugia and future source areas for repopulating what had been a depauperate region (Figure 4). As Wisconsin Age glaciations diminished and as Lake Agassiz filled, then retreated, various current day watersheds gained a biological signature strongly influenced by past geologic events, which have subsequently served as a foundation upon which current landscapes have been shaped.

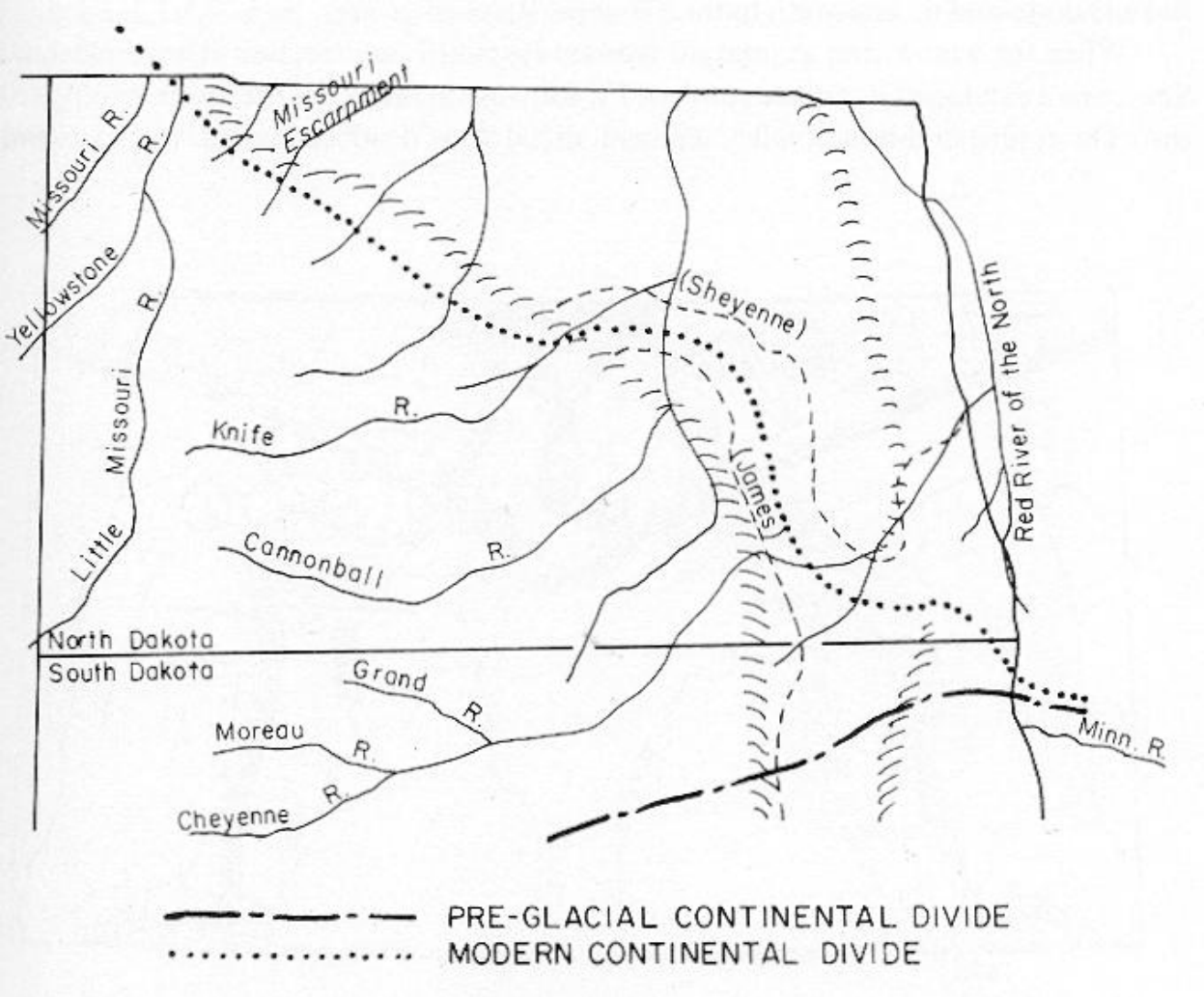

Figure 1. Landscape features such as continental divides are not fixed, and ecological attributes related to current species distributions must be interpreted within that dynamic context (from Brophy and Bluemle 1983).

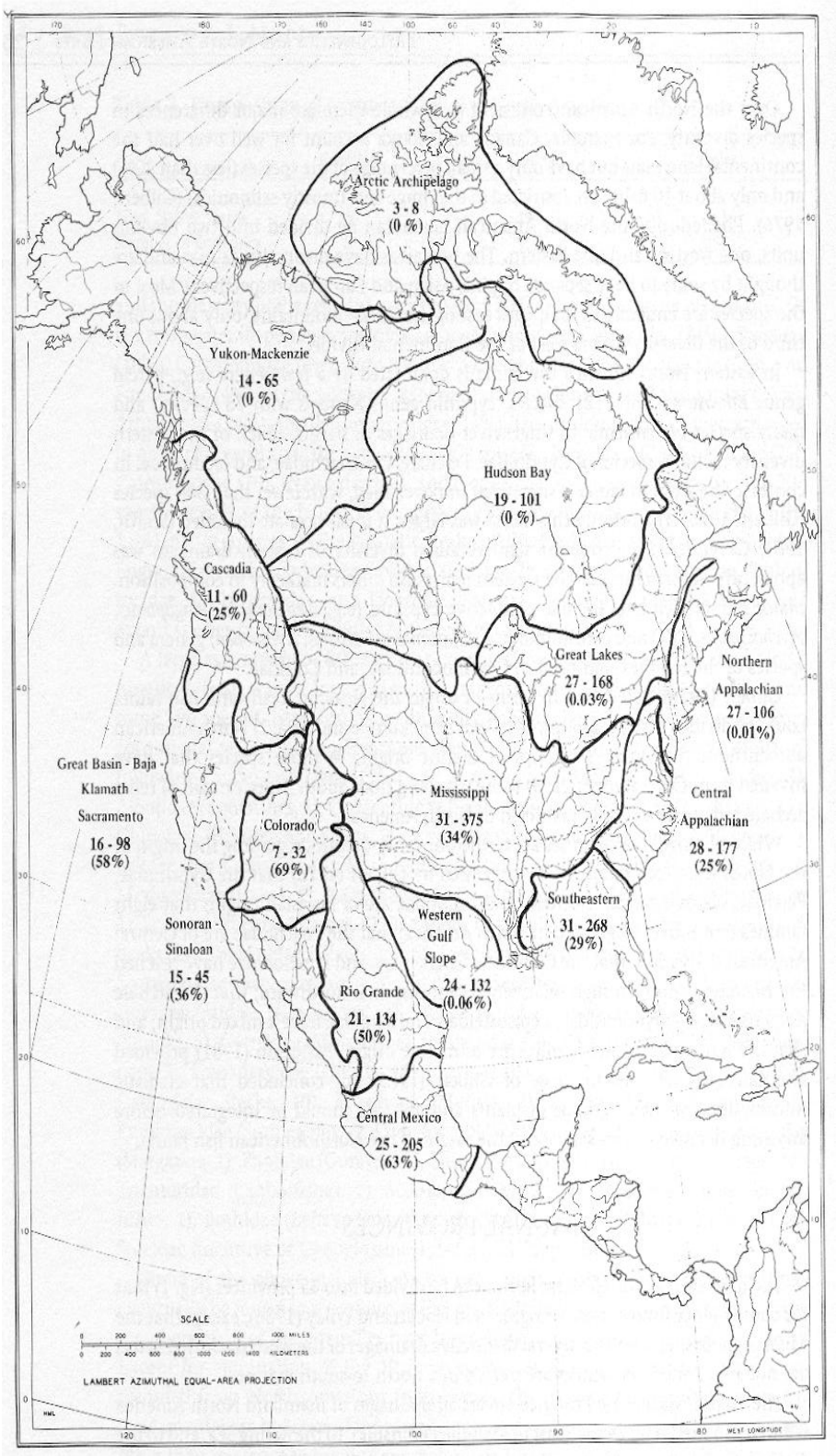

Figure 2. Provinces of Nearctic freshwater fishes with number of families listed, followed by number of species (percent endemics in province; after Burr and Mayden, 1992).

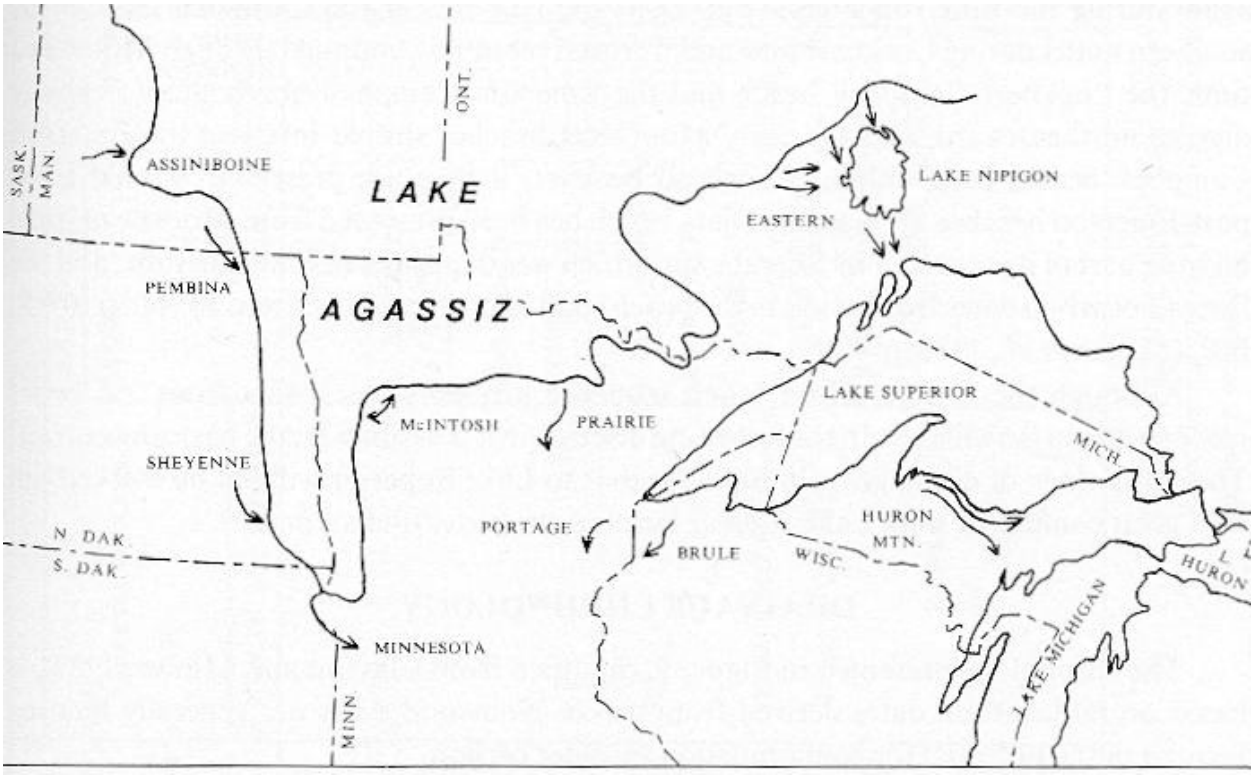

Figure 3. Spillways from glacial Lake Agassiz that historically linked nascent Red River basin flora and fauna with Upper Missouri River, Upper Mississippi River, and Great Lakes basins (from Clayton 1983).

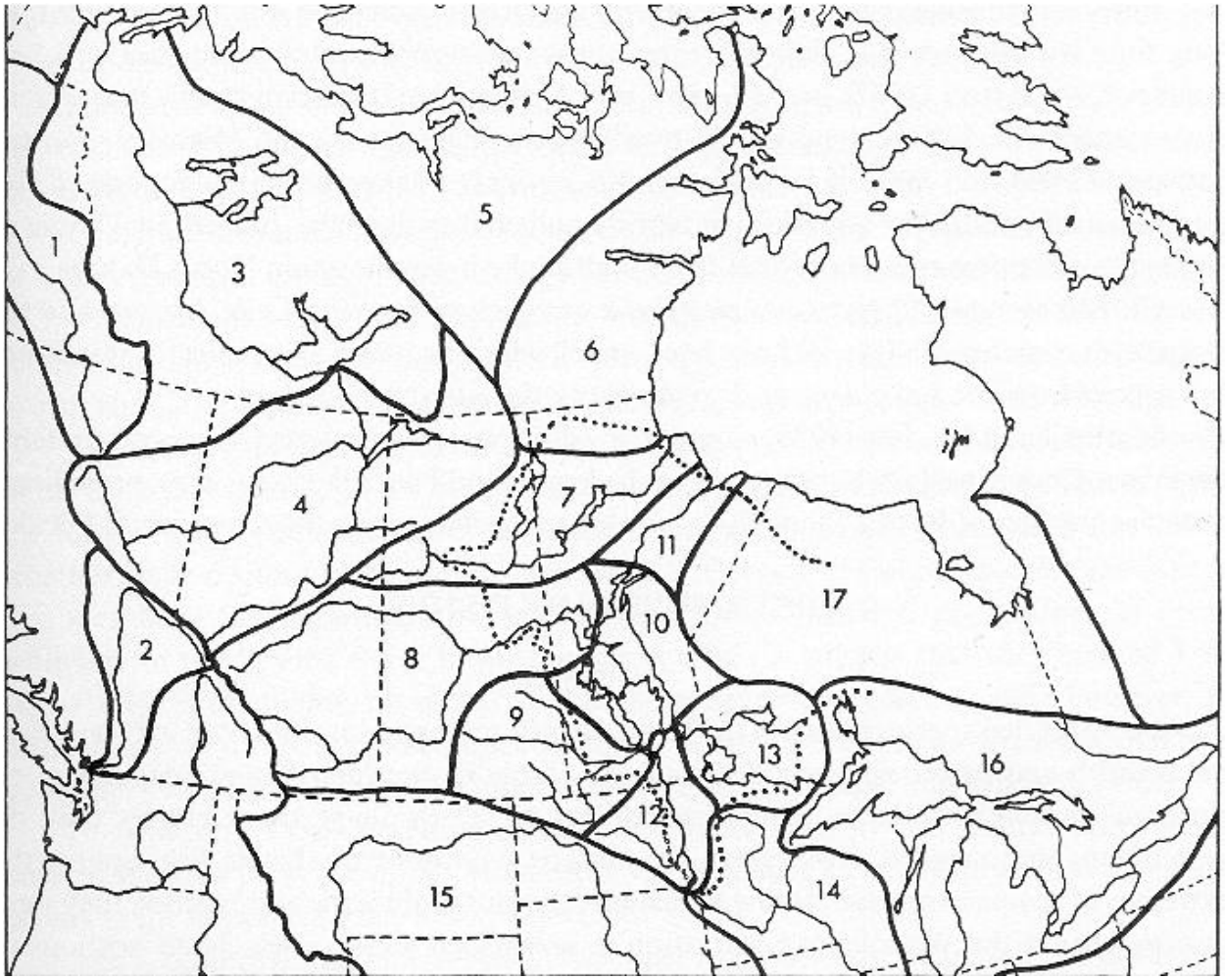

Figure 4. Recent surface drainages associated with glacial Lake Agassiz. Watersheds numbered 7–13 and 17 were directly influenced by glaciers of the Wisconsin Age and Lake Agassiz. In postglacial periods, other watersheds listed (Numbers 1–16) were colonized by species which dispersed via the Lake Agassiz and environs or contained glacial refugia from which species dispersed into the Lake Agassiz region (watersheds numbered 1, 14, and 15). The maximum extent of Lake Agassiz is indicated by a dotted line. (1) Yukon, (2) Fraser, (3) Mackenzie, (4) Athabasca, (5) Arctic Coast, (6) Hudson Bay, north of Churchill River, (7) Churchill, (8) Saskatchewan, (9) Qu'Appelle/Assiniboine, (10) Manitoba Lakes, (11) Nelson, (12) Red, (13) Rainy, (14) Upper Mississippi, (15) Upper Missouri, (16) Great Lakes, (17) Hudson and James Bay, south of Nelson River (after Stewart and Lindsay 1983).

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