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ADAPTATION OF HUMAN CULTURES TO WETLAND ENVIRONMENTS

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Abstract

Wetlands in most places and times have presented both resources and hazards to humans. Resources include food, water, cultivable soils, travel corridors, and refuge from human enemies and competitors. Hazards include soft soils, storms, flooding, and water-related diseases. Cultural adaptations allow use of wetland resources while reducing the effects of wetland hazards. I analyzed data on human cultures associated with wetland-dominated regions worldwide. Some of the environment-influenced traits of material culture are related to shelter, cultivation, travel, burial, and avoidance of biting flies. Many human groups build shelters outside wetlands and enter wetlands to harvest resources. Burial is most often in natural high ground. Cultural adaptations to biting flies and fly-vectored diseases include spatial and temporal avoidance of flies, use of smudge, protective clothing or shelters, and repellents of botanical origin. Culture complexes vary with environmental factors such as seasonal flood pulsing, tides, salinity, climate, and predominant economy (e.g., foraging, herding, cultivating, industrial). For example, pile shelter and flood recession cultivation are common in flood-pulsed non-tidal wetlands. Many similar traits appear in wetland regions distant from each other. Certain wetland-associated traits also appear in upland cultures (e.g., pile burial, mound cultivation), probably allowing diffusion of culture from one wetland region to another. Most or all documented human cultures have altered wetlands to mitigate hazards and exploit resources. "Primitive" cultures drained, filled, channelised, fertilised, planted, mined, burned, and overharvested wetlands but had less ability to cause damage because they had only hand tools. Analysis of cultural adaptations to wetlands facilitates understanding of archaeology, environmental psychology, responses to climate and hydrological change, resource management, and urbanisation. Many city-states and modern cities have developed in association with deltas and coastal wetlands where resources and trade opportunities are prominent, and such cities are vulnerable to wetland hazards. A modern challenge is to reduce the effects of wetland hazards on people while conserving wetland resources.

Key words: Biting flies; Cultivation; Cultural ecology; Hazards; Human cultures; Resources; Wetland adaptations

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1 INTRODUCTION

Distinctive environments influence the behaviour and culture of people who live there (Hardesty, 1977; Moran, 1989). Cultural adaptations to mountain, desert, seashore, and arctic environments have been analyzed cross-culturally (Hardesty, 1977; Moran, 1989), but little such attention has been paid to wetland environments despite the now-recognised importance of the ecosystem services provided by wetlands. An exception, although limited in scope, was Funk's (1992) analysis of Native American archaeological sites in relation to wetlands. With the changing social attitudes towards wetlands (e.g., Magnusson, 2004), ecologists must study the influences of wetlands on people as well as the influences of people on the landscape. The resulting knowledge will inform land use planning, conservation, and management of wetlands.

Wetlands have provided, and continue to provide, many resources to human populations, including food, fibre, cultivable soils, water, travel and trade routes, and refuge from other humans. Also, wetlands present hazards to human safety and health, including flooding, ice, fog, biting flies, water-related diseases, soft soils, dense harsh vegetation, and travel barriers. Wetlands are under increasing pressure from growing human populations and intensifying resource extraction in both developed countries and developing countries. In order to conserve wetland functions (i.e., ecological processes) and values (ecosystem services), we must understand wetland ecology including wetland-human interactions. These constitute both human effects on the environment and environmental influences on humans. From the human point of view, these interactions can be viewed as interplay between the harvest of resources and the avoidance of hazards.

In order to selectively take advantage of wetland resources and avoid certain hazards, human groups have developed cultural adaptations. These are culturally transmitted behaviours and technologies that make resource acquisition and hazard avoidance possible or more efficient. Cultural adaptations (equivalent to culture traits, as used here) include, for example, fishing with baskets, catching fish that are concentrated by falling water levels, making and using narrow-beam, shallow-draft boats to travel narrow waterways, building boats of bundled, robust, graminoid plants, cultivating a diversity of plots in hydrologically different habitats as a hedge against dry or wet growing seasons, and reckoning kin relations bilaterally (through both wife's and husband's lines) to afford access to a larger number of persons for resource harvesting activities. Many of these culture traits are also useful in non-wetland environments, thus are energetically efficient and able to diffuse among wetland regions separated by extensive uplands. Examples of such dual utility are pile-supported shelters which are built in flood prone areas as well as on rocky ground, and canoes which can be paddled in wetlands as well as on open waters (or even pulled on snowy ground. Some culture traits, such as canoes, require wetlands of substantial size for useful deployment, whereas others, such as use of cattail (*Typha*) pollen for food, only require a few square metres of cattails in a tiny pool.

Table 1. Human groups (cultures) discussed in this paper.
Additional references are cited in Kiviat (1991)

Group	Location	Environment[1]	Economy	References
Chippewa (Southwestern Ojibway)	Western Great Lakes states, USA	Nontidal marshes	Foraging, cultivation	Vennum, 1988
Dutch	Netherlands	Tidal & nontidal marshes & swamps	Cultivation, herding, industrial	Colijn, 1980; Bloemers, et al. 2010
Gidra	New Guinea	Mostly nontidal, swamp	Foraging, some herding (pigs)	Ohtsuka, 1983
Iatmul and Sawos	New Guinea	Nontidal swamp & marsh	Foraging	Gewertz, 1983
Irish (rural)	Éire (especially SW)	Nontidal peatlands, etc.	Cultivation, herding, some marine resources	Evans, 1943,1957; Gmelch, 1979
Kimam	West New Guinea, Indonesia	Nontidal & tidal marsh & swamp	Cultivation	Serpenti, 1965
Lowland Maya	México, Belize	Nontidal savannah, etc.	Cultivation	Turner, 1974
Lozi	Zambia	Floodplain marsh	Cultivation	Gluckman, 1941
Marsh Arabs ("Madan")	Al Hor; S Iraq, SW Iran	Mostly nontidal marsh	Herding, cultivation, fishing	Salim, 1962; Thesiger, 1964
Pomo	California, USA	Nontidal marsh	Foraging	Oswalt, 1996
Purari	Papua New Guinea	Tidal swamp	Foraging	Williams, 1924; Bell, 2009
Sami (Saami)	Northern Fennoscandia	Tundra, boreal forest	Fishing, herding (reindeer, sheep)	Lehtola, 2004
Seminole	South Florida, USA	Nontidal swamp, marsh	Foraging, fishing, cultivation	Weissman, 1999
"Squatters"	Hudson River estuary, New York, USA	Freshwater tidal wetlands, islands	Secondary foraging[2]	E. Kiviat, pers. obs.
"Swampers"	Okefenokee Swamp, Georgia, USA	Nontidal peatland, mostly forested	Secondary foraging, [2] some livestock & cultivation	Nelson, 2005
Uru	Lake Titicaca region (Bolivia)	Nontidal lacustrine marsh (high altitude)	Foraging, herding?, cultivation?	Vellard, 1954; Horn, 1984
Vietnamese	Vietnam	Marsh, swamp, mostly nontidal	Cultivation	Rambo, 1973
Warao	Orinoco delta, Venezuela	Tidal swamp	Foraging, cultivation	Suárez, 1968; Wilbert & Layrisse, 1980

[1]"Swamp" is a wetland dominated by woody vegetation, and "marsh" dominated by herbaceous vegetation, following American usage.
[2]Secondary foraging connotes a sector of an industrialised culture that has shifted to a foraging lifestyle.

2 METHODOLOGY

The aim of this paper is a qualitative, ecological analysis of environmental influences on human culture in and near wetlands. I reviewed information (mainly published) on perhaps 100 wetland-associated cultures, and analyzed 19 in detail (Kiviat, 1991). These cultures included small-scale non-industrialised cultures as well as modern cultures such as the Dutch and rural Irish, and secondary forager groups (Table 1). I refer to cultures in the present tense, although many of the phenomena discussed are no longer extant.

I am mainly concerned with identifying those traits that are related to the wetland environment and that presumably confer a fitness advantage on the actors. I focus on material culture (things made or used) because it is easier to document and more obviously related to the environment. I conceptualise strategies of adaptation (general approaches) constituting groups of tactics (specific behaviours or technologies). For example, shelter emersion is the strategy of elevating shelter above water, within which there are several kinds of emersion (pile emersion, mound emersion, etc.

A wetland culture is an identifiable human group (either extant or historic) living in a wetland dominated geographic region and using wetland materials for a substantial portion of food supply, shelter materials, fuel, or other critical resource (Kiviat, 1991). These cultures span a gradient from wetland-resident and very intimately wetland-dependent cultures (e.g., Marsh Arabs) to dryland resident cultures that obtain large portions of their resources from wetlands (e.g., rural Irish). The rural Irish, especially in the rainier southwestern regions of Eire, grew much of their food in wetland soils and obtain most of their heating and cooking fuel from wetlands. The Marsh Arabs of southern Iraq and a small part of southwestern Iran lived in permanent or seasonally flooded wetlands and obtained their construction materials, most of their food, and the raw materials for their exportable commodities from the wetlands. Examining this wetness gradient of culture allows a better understanding of the importance of wetland resources and hazards, and the tradeoffs in acquiring resources and avoiding hazards. Generically, I also use the term "wetland culture" to mean the complex of adaptive behavioural or cultural traits that is expressed flexibly in different human groups. The human groups ("cultures") referred to are listed in Table 1.

Many of the world's most extensive wetland regions are associated with the floodplains and deltas of large rivers, low-lying coasts, arctic permafrost, poorly-drained boreal landscapes, and a few endorheic basins. Some such regions have continuous wetland, whereas others have discontinuous wetlands like the lacustrine and riverine wetlands of the American Great Basin. A minimum extent of about 10,000 km^2 of wetlands is usually necessary for the development of a distinctive wetland culture (Kiviat, 1991). Each such wetland region is ecologically unique, thus offers an opportunity for divergent cultural adaptation. Some of these regions, having lost their aboriginal populations, were colonised by "secondary foragers," subsets of westernised or industrialised societies that inhabit wetlands seasonally or permanently to fish, hunt, and trap. Examples are the Okefinokee "Swampers" and the Hudson River "Squatters."

3 RESULTS AND DISCUSSION

At the most basic level of analysis, the ecological characteristics shared as general tendencies by wetlands translate to particular resources and hazards for human cultures (Table 2). Cultural adaptations allow exploitation of resources while coping with hazards in successful wetland cultures. Important strategies of adaptation include ability to move to resources and away from hazards, ability to use local resources and substitute them for missing resources, and selective use of wetland topography and hydrology to escape competing groups or monopolise resources.

Table 2. Ecological characteristics of wetlands and the associated resources and hazards for human cultures, as general tendencies. All characteristics are not present in all wetlands.

Ecological characteristic	Resources	Hazards	Cultural Adaptations
Water levels near ground surface; fluctuating	Water supply; Access for shallow draft boats; Travel & trade	Flooding; Barrier to travel	Canoes; Emersion of activities; Spatiotemporal adjustments; Adjustable clothing
Ice	Travelways: may improve	Unsafe & barrier	Sledges; Avoidance of

	access on foot or by vehicle in winter; Cut for refrigeration	during freeze-up & break-up; Interferes with boat access to wetlands; Forces fauna out of human reach; Damages structures	ice jam areas; Seasonal migration
High humidity, ground fogs, exposed to storm winds		Post-harvest food losses?; Mycotoxins?; Travel dangers	
Soft, unstable soils	Refuge from intruders & competing groups	Travel difficulties; Miring of humans, vehicles & livestock; Cultivation difficulties	Trackways; All-terrain vehicles
Fertile soils	Productive cultivation; Abundant wild plant & animal resources	Weeds	Cultivation strategies optimising moisture
Semi-aquatic mammals with water-resistant fur	Pelts for clothing, etc.		Valuable for garments, trade
High productivity of vascular vegetation that is commonly dense, tough, harsh, slow-decomposing	Food; Fodder & grazing; Construction & craft materials; Protection from intruders	Travel difficulties; Hard to see and move through; Hazard to skin, eyes	Protective clothing
Sheltered creeks & pools	Sheltered travelways; Recreation; Refuge from storms & other people	Getting lost in maze of waterways	Means of discerning & communicating location
High spatiotemporal heterogeneity due to interaction of sedimentation, microtopography & water level fluctuation	Different microhabitats for resource biota; Diverse resources available	Unpredictable patchiness of resources	Tracking resource availability; Food storage
Subject to storm surges & salinity intrusions		Hazards to shelter, cultivation, wild resources	
Refuge from some interspecies interactions (predation, competition, herbivory, etc.)	Spatiotemporally abundant resource species	Missing species	Resource substitutions
Lack of stone or wood		Missing materials	Substitution of materials
Local abundance of biting flies (mosquitoes, etc.)	Protection from intruders	Fly-vectored diseases (malaria, etc.); Nuisance	Tight shelter; Repellents; Smudge; Seasonal migration; Avoidance; Clothing; etc.
Concentrations of fish, birds, other animals	Food; Recreation	Nuisance or dangerous species (predatory, venomous, disease-transmitting)	Harvesting fish, water birds, etc., at concentration points
Many animals are part-time (permeant) users	Locally abundant aggregated food animals	Spatiotemporal patchiness of resource species	Harvests focused on aggregations
Water-related diseases	Refuge from other people	Diseases, parasites	Avoidance; etc.
Accumulation of nutrients & toxins	Fertility for cultivation	Toxicity	Spatial selectivity

Some human activities in wetland are unique or different from those in upland environments, and these activities take advantage of ecosystem services that are unique or quantitatively greater in wetlands. The “adaptative framework” and strategies of wetland culture includes:

Emersion: Raising activities above water or saturated soil.

Permeant behaviour (see Shelford, 1963:15): Moving between wetland and upland habitats on various cycles to escape hazards (e.g., biting flies, flooding) or harvest resources.

Mobility and flexibility: Diversifying the use of resources in space and time, aided by travel technology (e.g., the canoe), equipment for acquiring resources, land use (cultivating plots with different moisture regimes), and social structure that facilitates the efficient exploitation of resources (e.g., arrangements that make more people available quickly to participate in a resource-related task such as fishing).

Other technology (e.g., for protection against biting flies or substituting local materials for stone and wood).

This framework is expressed in solving several key problems of wetland use.

3.1 Shelter

Shelter is a fundamental aspect of culture because it modulates the microclimate within a range that is safe and comfortable. Shelter also helps protect from predators and disease vectors. In general, shelter architecture reflects local culture, environmental constraints, and available (local or imported) construction materials. In wetlands, the principal problem is emersion, i.e., elevating the floor above water or wet soil. Shelter emersion (Figure 1) is accomplished by construction on high ground (dry shelter), construction on pilings or stilts (pile shelter), construction on an artificial island (mound shelter), or a floating platform (raft shelter).

The Marsh Arabs of the permanently flooded marshes of Al Hor build islands of reeds (*Phragmites karka*) and sediments. These islands, large enough for a single home or the much larger guest house of a Sheikh, are continually added to and are long-lived. On the seasonally flooded plains of the Tigris and Euphrates region, Mesopotamia, extending from the permanent marshes, many archaeological sites are associated with *tells* which are ancient, artificial or semi-artificial mounds built of soil and other materials (Menze et al., 2006). Many buildings and even whole towns in the modern Netherlands are situated on longstanding artificial mounds called *terps* (Evans, 1978:125; Nieuwhof, 2010). In some places (e.g., the Purari; Williams, 1924:8, 11, 28), habitation mounds built up over time as middens of trash.

Some types of wetlands provide materials of high quality for shelter construction. Forested wetlands of provide hardwood trees, conifers, or palms. Herbaceous wetlands provide robust graminoid plants, and some tropical swamps provide palms. Examples are the moriche palm (*Mauritia flexuosa*) wood used by the Warao of the Orinoco delta tidal swamps, as well as the 7 m tall reeds used by the Marsh Arabs and the giant bulrush (*Schoenoplectus californicus* ssp. *tatora*) used by the Uru of the Lake Titicaca region. The Uru and Marsh Arabs are the best examples of cultures based largely on single plant species.

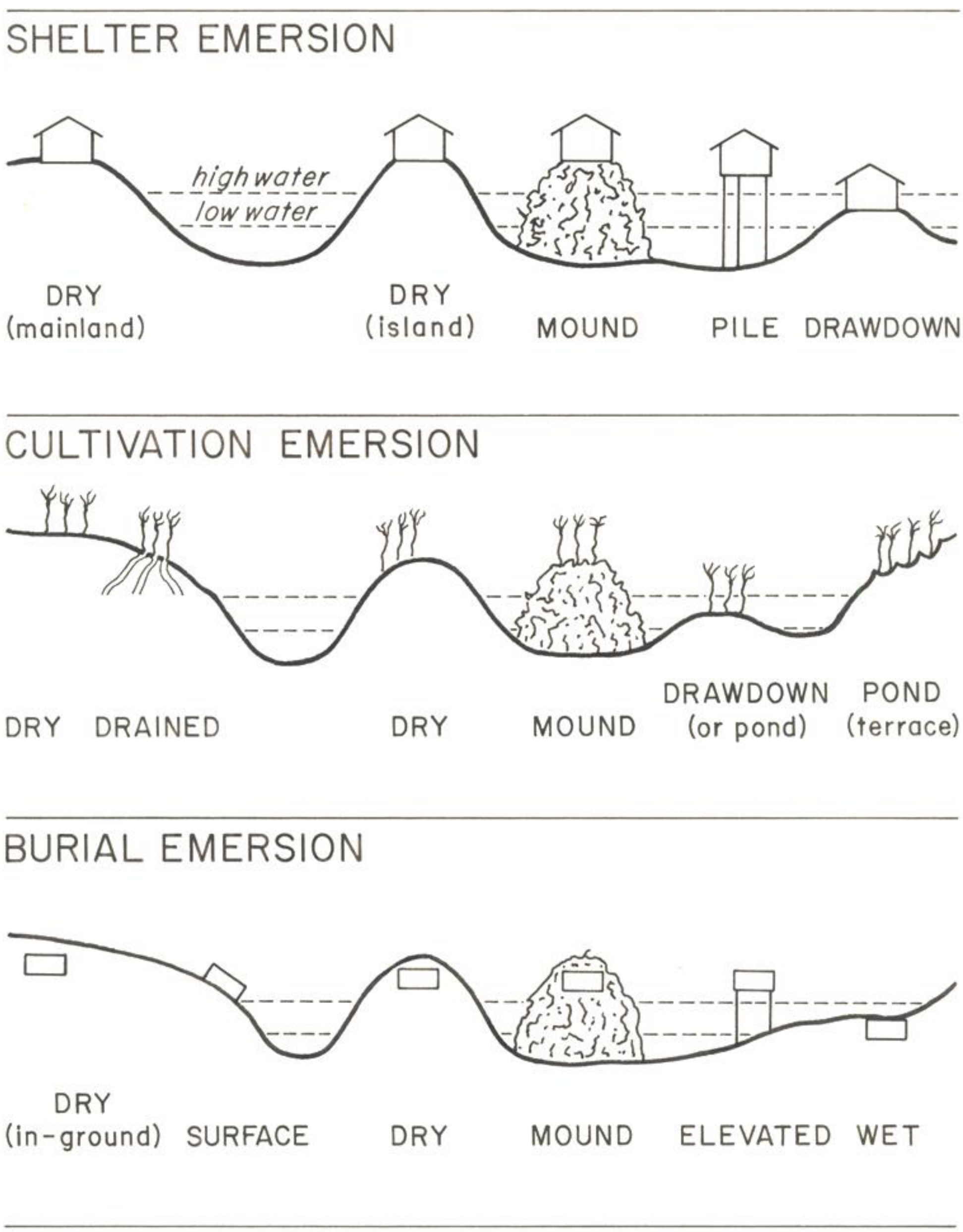

Figure 1. Emersion of human activities above water or saturated soil (vertical dimension exaggerated). Drawn by Kathleen A. Schmidt and reprinted from Kiviat (1991).

3.2 Cultivation

In order to overcome the constraints of soft saturated soils and exploit the fertile environment with ample water, cultivation in wetlands requires adjustment of crop to hydropattern (Figure 1). Also, human groups as diverse as Vietnamese and Lozi cultivate multiple plots in different hydrological settings as a hedge against unpredictable water levels (Kiviat, 1991). Drawdown cultivation, mound cultivation, pond cultivation, and dry cultivation are common forms of emersion; raft and pile cultivation are rare. Pond cultivation involves bunding or excavating to create deeper-than-ambient waters at least seasonally, and reaches its most common and complex expression in wet (padi) rice. Other forms of pond cultivation involve pits excavated for growing taro (*Colocasia*, *Alocasia*) in the Pacific islands, wasabi (*Wasabia japonica*) in Japan, and water-chestnut (*Trapa natans*) in India. Drawdown cultivation or flood recession agriculture involves planting as flood waters recede to take advantage of the low water season in which moisture levels are suited to a variety of upland crops. Mound or ridge cultivation is widespread and was extensive, for example, among the Lowland Maya (México, Belize; Turner, 1974) and the rural Irish (Evans, 1957:141-

143). Soil is excavated from the intermound areas and piled up to form the mounds or ridges upon which most of the crops are planted.

Two interesting tidal wetland agronomies were practiced in the U.S. Estuarine rice (*Oryza* sp.) farming on the southeastern rivers used estuarine hydrology to maintain a suitable habitat for high productivity of wet rice; this agronomy was imported from West Africa by enslaved Africans (Carney, 2009; Kiviat, 2009). Salt hay, principally *Spartina patens* (a native plant), was managed for harvest in altered salt marshes on the northeastern coast (e.g., the New Jersey Meadowlands; Quinn, 1997). Both crops required complex hydrological alterations of wetlands that were difficult to maintain, and both were economically and culturally important.

3.3 Other wetland food resources

Changing water levels, large scale seasonal migrations, and other factors often concentrate wetland animals. People commonly take advantage of such concentrations of fishes, water birds, and mammals. Fish are harvested from drying pools or caught as they are funneled through narrow channels. Mammals are harvested from restricted areas of surface water during drought (water holes), and from restricted high ground during flood.

In other cases, harvest of wild animals and plants for food simply exploits the high productivity of wetlands. Harvest of snapping turtle (*Chelydra serpentina*) and diamondback terrapin (*Malaclemys terrapin*) from dense marsh populations in the eastern US (Schwartz, 1961; Kiviat, 1980) fits this pattern. Turtles are exploited almost universally, whereas use of frogs for food is irregularly distributed (Kiviat, 1991).

In some cases, large patches of particular plants facilitate collection of foods, such as wild-rice (*Zizania*) seed (Chippewa). or cattail (*Typha*) pollen. Cattail pollen is an interesting case because pollen is rarely collected for food but cattail is used for this purpose in the US, India, and the Middle East (Kiviat, 1991).

There is a fascinating parallel between use of moriche palm by the Warao (Venezuela; Wilbert & Layrisse, 1980) and sago palm by New Guinea groups (e.g., Gidra; Ohtsuka, 1983). Similar techniques are used to extract the starch, and in both cases a large lepidopteran larva that feeds on the respective palm is also eaten.

3.4 Missing materials: wood, stone, and metals

Many wetlands regions underlain by peat, silt, or sand lack stone of appreciable size for raw materials. Non-tree-dominated wetlands may also lack wood, a particularly harsh condition. Various hard materials are used as substitutes, notably including bone, antler, mollusk shell, and vertebrate teeth (Kiviat, 1991). Robust graminoid plants tied in bundles may substitute for wood. Missing materials may be imported, via trade, in raw or manufactured form, as are the plank canoes of the Marsh Arabs (Thesiger, 1964). Irish mined fossil wood from the bogs (Lucas, 1954).

3.5 Travel

Trackways or boardwalks are often built in simple or sophisticated forms, to facilitate walking on or above soft or flooded soils. Trackways were prominent in ancient northern Europe (e.g., Casparie, 1987), and elevated boardwalks connected the dwellings of the Warao. Riding stock (e.g., reindeer among the Sámi and horses among the Marsh Arabs of Iran) are uncommon although locally important. A few groups construct types of all-terrain vehicles, such as a Sami sledge which could cross water, ice, snow, or soft sediment.

The canoe, in numerous forms (Figure 2), is widespread. Canoes are made from logs (dugouts), planks, bark, or bundled graminoids (e.g., reed [*Phragmites*], bulrush [*Schoenoplectus*] or papyrus [*Cyperus papyrus*]). Commonly canoes are pointed at both ends, probably for hydrodynamic efficiency and to facilitate backing out of narrow channels. A single-bladed paddle is common and functions well in narrow channels as well as broader waters. Double-bladed paddles are used in some groups. The lighter kinds of bark or graminoid canoes can carry substantial weight without drawing much water, but can readily be carried from one water body to another.

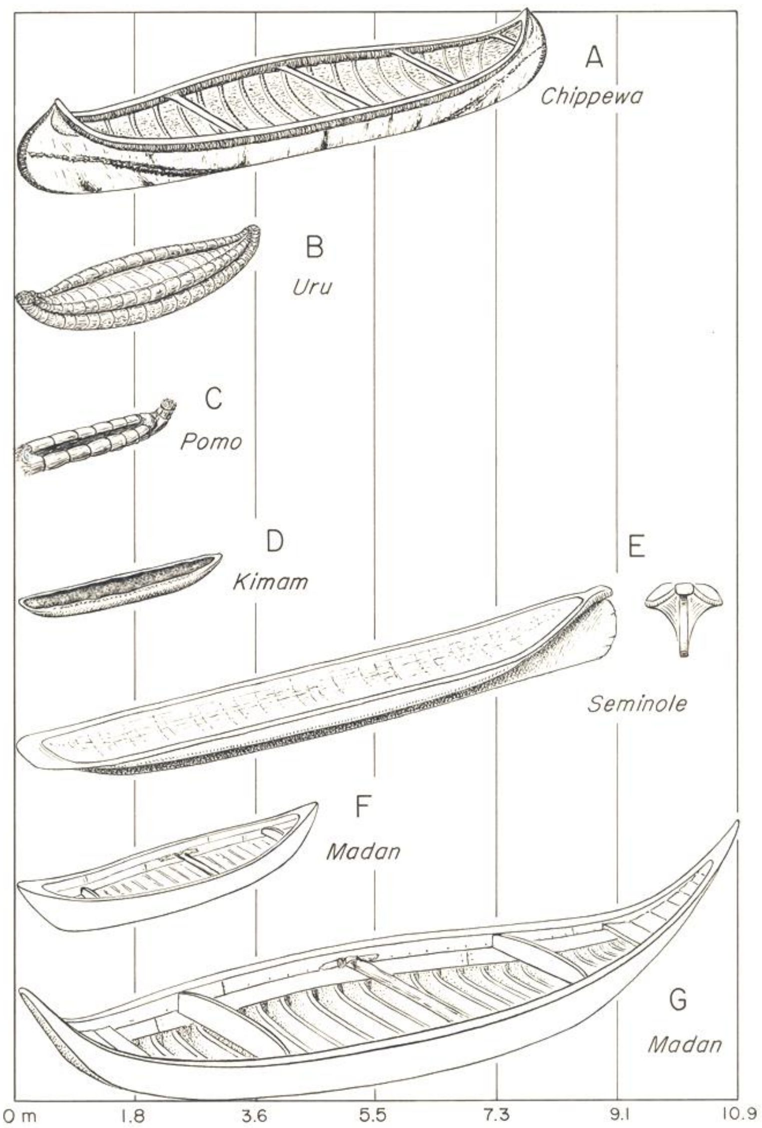

Figure 2. Examples of canoes from wetland cultures. A is a bark canoe, B and C are reed canoes, D and E are wooden dugout canoes, and F and G are wooden plank canoes. Drawn by Kathleen A. Schmidt and reprinted from Kiviat (1991).

3.6 Burial

Burial in water or wet soil is unusual. Commonly burial occurs in dry ground, in surface tombs, or occasionally on piles (Figure 1). Ecological reasons for the aversion to burying relatives, friends, or leaders in wet substrates are not obvious (Kiviat, 1991). Transmission of water-related pathogens, such as cholera, and parasites, such as giardia, would seem the most parsimonious explanation. Also, burials in wet soil may be unstable and corpses may float with rising water levels. Disposal of bodies in wetlands is often "negative" burial. Prominent examples are the "bog bodies" of Neolithic northern Europe (e.g., Turner & Briggs, 1986) many of which were the victims of ritual sacrifice, and the disposal of murder victims in the New Jersey Meadowlands (e.g., Sullivan, 1998).

3.7 Protection against biting flies

Many of the mosquitoes (Culicidae), horse flies (Tabanidae), black flies (Simuliidae), biting midges (Ceratopogonidae), sand flies (Psychodidae), tsetse flies (Glossinidae), and a few other minor taxa of biting Diptera (true flies) are closely linked to wetlands ecologically and psychologically. These insects collectively constitute some of the most dangerous hazards associated with wetlands, both in their role as disease vectors and their ability when very abundant to directly harm humans or domestic animals. Wetland cultures have many means for reducing the impacts of biting flies. These include building shelters in habitats with fewer flies (e.g., areas exposed to wind), elevating structures above the ground, tight shelters or sleeping bags, smudge fires inside or outside shelters, stabling livestock close to human sleeping areas to divert flies from people, timing outdoor activities to avoid peak biting periods, using a great variety of herbal or mineral repellent and barrier materials applied to skin, and migrating to relatively fly-free areas during peak biting season (Kiviat, 1993). It is interesting that many still-used culinary spices and herbs, and well as cosmetic scents such as sandalwood (*Santalum*), myrrh (*Commiphora*), and patchouli (*Pogostemon*), are reported to have repellent properties (Kiviat, 1993).

3.8 Transhumance

Groups that herd domestic ungulates often move them seasonally to access better forage, drier pasture, or areas with fewer biting flies (Kiviat, 1991). For example, in coastal Louisiana, USA, cattle are moved seasonally between fresh marshes and salt marshes (Miller, 1956).

3.9 Refuge

Wetlands, especially extensive ones, provide a refuge from military predation, socioeconomic dominance, religious persecution, competition for resources, law enforcement, and even disease. This operates because human groups that are culturally adapted to life in wetlands can thrive where non-adapted groups cannot, or even evade pursuit through difficult terrain. At least occasionally, a group has avoided contagious disease by taking refuge in a wetland region where infected populations do not penetrate; the best example is the Warao (Wilbert, 1983). The Marsh Arabs reportedly were formed from diverse groups that took refuge in Al Hor over millennia, and continue to absorb refugees from military conflicts. The Seminole of the Big Cypress Swamp and Everglades of southern Florida (USA) were originally groups from farther north that fled domination and learned to exploit environments where the U.S. Army could not successfully pursue them.

People generally select higher ground, such as islands, natural levees bordering channels, or upland margins, to locate shelters and for certain other activities. Because high ground may be in short supply, those groups that are dominant militarily or economically may monopolise favorable topography (as well as important natural resources or lucrative trade routes). Examples include the Iatmul and Sawos on the natural levees and backswamps of the Sepik River in Papua New Guinea (Gewertz, 1983), and villagers on the active delta and stabilised delta regions of West Bengal, India (Nicholas, 1963).

Wetlands, with complex waterways and vegetation, and barriers to travel, are often hiding places for criminals and outcasts. Among these are pirates, illegal immigrants, and smugglers. “Moonshiners” (making illegal alcoholic beverages during the U.S. Prohibition Era of the early 1900s) often worked in wetlands or mountains difficult of access for law enforcement agents. Although wetlands undoubtedly are used for many illegal, clandestine, or unpleasant activities, these environments may have an exaggerated reputation for criminality.

3.10 Alterations to wetlands and cultural evolution

Human modification of wetland soils, hydrology, and vegetation is nearly universal. Alterations function to improve the ratios of resources to hazards, including facilitating travel, cultivation, and avoidance of biting flies. We are accustomed to wetland alterations by means of heavy equipment, whereas non-industrialised groups with only hand tools, given enough labor and time, were able to alter large areas. The raised fields built by the Classic Maya on hundreds of square kilometres of wetlands in Central America are a well-documented example (Turner, 1974).

The widespread ancient practice of sculpting wetland soils into ridges and furrows (raised fields) has parallels in the modern world. Grid-ditching for control of salt marsh mosquitoes was widespread on the northeastern and Middle Atlantic coasts of the U.S. In Florida and other coastal regions of the U.S., mangrove swamps and other wetlands were dredged and filled to create mosaics of raised substrates to support houses and channels for recreational boating. And now, in the New Jersey Meadowlands, wetland mitigation often involves excavating pools and creeks in formerly tidal marshes and piling the dredged material into islands intended for water bird nesting. The common feature of all these alterations is raising and lowering substrates to turn wetlands into a combination of dry land and shallow water.

The ability to alter wetlands via drainage, channelisation, filling, clearing, burning, etc., is related to the development of cultural complexity. Modern industrialised groups are able to modify wetlands rapidly and extensively by means of heavy mechanical equipment powered by fossil fuels. Historically, alteration of wetlands and water bodies for irrigation, drainage, and other purposes (along with other factors including trade) allowed the development and success, at least temporarily, of complex cities and city-states in Egypt, Mesopotamia, the Indus River basin, Angkor, the lower Mississippi River basin, the Valley of México, the Mayan Lowland, and other locations. To the extent understood, all of these "civilisations" suffered bad periods or met their ends due substantially to wetland and fluvial processes such as flooding, siltation, salinisation, tectonic-hydrologic changes, or conquests by more powerful groups seeking wetland and aquatic resources.

3.11 Applications

Wetland regions such as the Okavango Delta (Botswana) and Al Hor (Iraq, Iran) will likely be managed to integrate conservation of biodiversity and survival or revival of the cultures that depend on it. Traditional cultures have impacts on the environment that can be substantial. However, many cultures or elements thereof illustrate relatively low-impact, sustainable indigenous management systems. Some of these systems can be conserved or restored in approximately their intact form, whereas others may yield ideas for more sustainable future systems. Analysis of traditional wetland cultures can be a mirror to our modern relationship with wetlands, facilitating understanding of our present and future relationship to the environment. Discovery of general patterns in human use of wetlands informs analysis of fragmentary information from archaeological sites (see Coles & Coles, 1989; Funk, 1992).

Traditional ecological knowledge (e.g., Menzies, 2006) can be a source of ideas for improvement of modern technologies and procedures. Many natural plant products are being tested for their insect repellent properties, and some have been found to be effective (Nerio et al., 2010). There are other extant and potential applications in agronomy, such as hydrophytes and halophytes with traditional uses (National Academy of Sciences, 1976; Rozema & Flowers, 2008). The concept of pile shelter in wetlands has been adapted in southern Florida (USA). The second storey is the living space, and the ground storey (the space between structural pilings) is used for a carport, with electrical wiring located above the predicted storm surge level.

Understanding the strategies of avoiding biting flies (Kiviat, 1993) helps us raise questions about how to mitigate the impacts of emerging and resurging vector-borne diseases such as West Nile virus and malaria in the U.S. Structures can be sited on the upwind side of fly-producing wetlands and exposed to the wind, and elevated above ground level where most of the biting flies forage. (It should be noted that biting flies are typically concentrated at wetland edges or in certain wetland habitats, and fly foraging activity is concentrated at certain times of the year, day, and weather.)

Many wetlands are being actively managed, restored, or created. Most temperate and tropical wetlands can sustain certain levels of human activity and resource use, and it is commonly appropriate to protect wetlands by allowing and managing human use. Traditional cultural adaptations may suggest techniques or approaches to improve the environmental quality of wetlands and the balance of resources and hazards for human use without diminishing native biodiversity. Boardwalks (raised trackways) protect from miring the people who visit wetland nature reserves and allow access for wildlife viewing with reduced disturbance to the wildlife and soils. Boardwalks have been installed in many wetlands; a particularly good example is at Corkscrew Swamp, Florida, U.S.A. Because boardwalks are subject to damage from fungi, insects, and ice, some are constructed from resistant woods of wetland trees such as bald-cypress (*Taxodium distichum*) or Atlantic white cedar (*Chamaecyparis thyoides*). The sustainable husbandry of livestock by cultures such as the Marsh Arabs (water buffalo) provide examples for environmental livestock production in the future.

4 CONCLUSIONS

Worldwide, many human groups live in wetlands or depend on them for a substantial portion of food, construction and craft materials, fuel, refuge from other people, or other resources. Wetland-associated groups also cope with wetland hazards, including flooding, travel difficulties, biting flies, and water-related diseases. Wetland cultures (the collective behaviours of wetland-associated human groups) evince culture traits that are adaptive in wetland environments. Notable traits are those related to travel (e.g., canoes), emersion of shelter, cultivation, and burial above water or saturated soil, movements and foraging techniques related to the hydropattern (e.g., harvesting animals concentrated by water levels or flows), and use of wetland species (e.g., robust graminoids for construction shelters or boats, cattail pollen for food).

Analysis of wetland cultures provides information useful in interpreting archaeological data and for adaptation to sea level rise and storm surges. Traditional knowledge of wetland habitats and species suggests future use of wetland resources for food, fuel, and fibre. Consideration of the duality of wetland resources and hazards helps explain current attitudes towards wetlands in developed countries.

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