Choice experiments for ecosystems and wild birds: An overview of the literature and transferability of benefits functions

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1 Introduction

Wild birds are generally a non-market environmental good, with few market-based opportunities to measure rigorously the benefits accruing to society from policies or programs that help to support their abundance and biodiversity. Economists, therefore, must often resort to survey-based questions about the types of trade-offs that people are willing to make among the attributes of different ecosystem management alternatives under consideration. This "stated preference" methodology includes both "choice experiments" and "contingent valuation," where the latter is a simplified choice experiment with just a single bundle of attributes to be valued, and where the cost of that bundle is the only attribute that is varied experimentally.[1]

In this chapter, we review a selection of published papers that rely on choice experiments, as well as some studies that use contingent valuation, as non-market valuation methods that can be helpful for understanding the tradeoffs that people are willing to make to protect either individual wild bird species, categories of species (guilds), or the habitats upon which these species rely. Our review focuses on the features of these studies that make them more or less suitable for "benefits-function transfer," where the policy-related usefulness of the original research can be multiplied by transferring the estimated models to predict benefits associated with other types of wild birds in other regions.

Stated preference studies are usually designed based on the objectives of the original study and may or may not be crafted to anticipate their use in subsequent benefit-function transfer exercises. Agency analysts often must draw from a limited number of studies and location-specific values when conducting benefit-transfer exercises for programs, regulations, or policies involving conservation benefits (Holmes (2020); Newbold et al. (2018). We find that very few of the studies in this inventory optimize their prospects for future benefits-function transfers, so we look very closely at study features which limit these prospects in each case. Most

[1] We refer readers to Johnston et al. (2017) who provide an update to an earlier summary of best practices documented by the 1993 NOAA Blue Ribbon Panel report (Arrow et al. (1993)). Thorough textbook coverage is also available (e.g., Champ et al. (2017); Mariel et al. (2021)). We note, of course, that in contingent valuation studies, the nature of the bundle of attributes to be valued can be changed across a set of questions, allowing people's choices to be modeled using essentially the same tools as are used for choice experiments with the data pooled across the different choice tasks.

of the studies we review here were intended to value just one species, or a few species, in a particular area. We use these examples to highlight how researchers can design future studies to satisfy the demands of the initial narrowly defined valuation task, but simultaneously strive to produce a study that will have follow-on usefulness for other related valuation exercises.[2]

Efforts to anticipate future usefulness of each choice-experiment study are important because government agencies may or may not have the resources to commission a new study to value every species of wild bird in every ecosystem in their jurisdiction. Often instead, they must rely on "benefits transfer" or "benefits-function transfer" during their program evaluations or regulatory reviews. These evaluations and reviews typically require estimates of the *benefits* to wild birds or their ecosystems, to be weighed against the *costs* of policies or programs to protect them. Rosenberg et al. (2019) highlighted the precipitous population losses for North American avifauna over the last five decades, highlighting concerns of population declines for a variety of bird species beyond iconic, threatened, or endangered species. These striking population losses have spurred ecosystem managers to pay more attention to the impacts of programs and policies on wild bird populations, increasing the demand for benefits estimates that will be useful for benefits transfer.

A growing number of choice experiments in the published literature concern wild birds and the ecosystems which support them. These papers have appeared in environmental economics journals, as well as in journals that publish interdisciplinary research on sustainability topics targeted towards broader audiences. We organize the material in this chapter according to topics that researchers will likely need to consider in the process of devising any new choice-experiment study. We start with an overview of the types of published studies to date and discuss some of their important features. Next, we provide an overview of the estimation methods, modeling, and decisions about how to specify variables, as well as practical information to consider when designing a survey. We then provide a discussion about additional study features to facilitate the use of the results to estimate a "benefits function" that can be transferred to new contexts where (a) the population of birds and their ecosystems may have different attributes, and/or (b) the relevant human population may have different characteristics. In our final section, we offer a specific set of "Considerations" for choice experiments that seek to value wild birds and their habitats, based on the main lessons learned from our review of the literature. These considerations will often be very important to the follow-on usefulness of the substantial effort and expense that typically goes into any valuation exercise using survey-based choice experiments.

2 Literature Review

Studies in this literature emphasize different types of benefits that people derive from wild birds as well as the habitats that support these birds. For example, the demand for bird sanctuaries or protected areas may be characterized as a derived demand based on what those sanctuaries contribute to the maintenance of wild bird populations, although there can also be direct demand by people for the ecosystems themselves.

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[2] Reviews of best practices in benefits-transfer exercises (e.g., Johnston et al. (2021)) tend to emphasize what features are prudent to take into account in choosing a study (or set of studies) available to use in a benefits-transfer exercise. We move one step back and focus on how to design original studies that will be more useful for benefits-transfer applications.

Many of the early stated preference studies used contingent valuation methods, with choice experiments becoming more common in the last two decades. Some studies focus on a single site (e.g., nature reserves and similar specific locations or a non-protected locations) or a specific type of ecosystem (e.g., urban, conifer plantations, etc.) whereas others focus on a broader region (e.g., state, country, or global region).[3]

Other types of studies use choice experiments concerning bird species across broader geographical areas or jurisdictions relative to a particular scenario, ranging from conservation (e.g., policies, payment for ecosystem services, etc.) to market goods (e.g., caged birds). With a sufficiently representative sample, the preferences elicited by these choice experiments could, in principle, be employed to value these species in other habitat areas in that region. Sometimes, however, the funding for a study dictates the geographic scope of the sample, even though the species in question may be present in other areas or may migrate across a much wider area.

In the first subsection below, we acknowledge the range of potential benefits that wild birds may provide to humans. The ensuing subsections review the range of different foci of the choice experiments in our inventory—including valuing iconic, threatened, and endangered species; valuing birding in general, including birds or sites for tourism or bird-related recreation (bird watching and hunting); environmental damages; the public's willingness to pay (WTP) for protection or enhancement of wild bird populations or their habitats, farmers' willingness to accept (WTA) payments for practices that improve ecosystem services; and other cultural ecosystem services.[4]

2.1 Brief review of ecosystems services provided by wild birds

Given the usual page limits for journal articles, many papers mention only in passing the variety of ecosystems services provided to humans by wild birds and their habitats. This topic is often confined to the paper's perfunctory description of the introduction to the choice experiment survey. Many survey respondents may not have thought much, in advance taking the survey, about specifically why they might value wild birds or bird habitat. Furthermore, the demand for

[3] A shortcoming of studying one specific wildlife/bird refuge or a single biodiversity hotspot is that such studies risk producing results that are relevant only for the unique site in question. If this is the case, the study's findings, used alone, may not be generalizable for benefit transfer from the "study" site to other "policy" sites. There may be a set of unique attributes of the study site which remain implicitly constant while other attributes are varied in the choice experiments. These unique attributes may influence the tradeoffs people are willing to make with respect to the wild-bird-related attributes at the study site. The manner whereby any different unique attributes for any other policy site affect tradeoffs at that site may be unknown.

[4] In the Supplementary Materials associated with this chapter, we have assembled a spreadsheet with one row for each study, and with one column for each of a long list of study features. The spreadsheet format seemed a useful adjunct to this review because it permits easy direct comparisons across studies for a huge number of study features, and these can also be sorted and searched. In addition to the set of study features reviewed in the body of this paper, we include additional details about elicitation methods, modeling considerations (such as the use of continuous versus categorical attributes, or the use of interactions between attributes), any ultimately monetized values for specific types of wild birds), along with additional caveats and recommendations for future research (both those that are offered by each study's authors, and additional points gleaned from this review). The most-complete characterizations in our spreadsheet are for papers that involve choice experiments, but the inventory also includes mentions of numerous contingent valuation studies that also seek to value wild birds or wild bird habitat, either directly or indirectly.

wild birds is likely to be just one facet of people's demands for "nature" in general.[5] Ecosystem services are provided by wild birds within each of the four categories of services identified by the United Nations Millenium Ecosystem Assessment. These categories are: (1) provisioning services (e.g., food, bird feathers), (2) supporting services (e.g., nutrient cycling, seed dispersal, and pollination), (3) regulating services (e.g. pest control and scavenging) and (4) cultural services (e.g., birdwatching and ecotourism) as shown in Table 1 (gleaned from Bennett and Whitten (2003) and Whelan et al. (2008)).

Table 1 Example of Ecosystem Services Provided by Birds.

Ecosystem services of wild birds	Examples of bird species	Service category
Food/meat provision; birds are hunted both for subsistence consumption and for recreation	Waterfowl, upland gamebirds; e.g., galliforms	Provisioning
Bird feathers; e.g., used for bedding and insulation, or for ornamentation	Geese, many species	Provisioning
Pollination of wild and cultivated plants	Hummingbirds	Provisioning
Nutrient cycling; e.g., moving nutrients from fresh- or salt-water ecosystems to terrestrial ones	Waterbirds, and waterfowl; e.g., cranes, puffins	Supporting
Seed dispersal	Passerines	Supporting
Ecosystem engineering	All bird species	Supporting
Predators; e.g., limiting rodent populations	Owls, raptors	Regulating
Pest control; e.g., herbivorous insects	Many bird species	Regulating
Scavenging; e.g., to regulate human diseases spread by carrion	Kites, vultures, ravens	Regulating
Bird watching/ecotourism	All bird species	Cultural

2.2 Valuing iconic, charismatic, threatened, and endangered species and places

Studies in this literature have long focused on one species or just a few species as they relate to conservation or tourism. Sometimes, one or two species of birds are singled out among generic populations of other birds. The species of interest are often chosen because they are iconic, rare, threatened, or endangered. Other researchers seek to value several species, or focus on a specific habitat, or focus on conservation outcomes of particular interest to tourists.

[5] In other valuation contexts, for example, the goal may be to identify people's willingness to pay for a policy that prevents damages to a specific environmental good. However, it can be difficult to keep respondents from factoring in their subjective expectations about any likely human health effects that might be associated with each alternative management strategy. People make choices based on their subjective understanding of what would be likely to happen under each proposed option in a choice experiment, despite the researcher's usual exhortation to "assume that everything else would stay the same." This tendency by respondents to assume that other things will, in fact, also change has been described as subjective "scenario adjustment" (see Cameron et al. (2011)). It is sometimes possible to follow up with debriefing questions to confirm whether respondents made their choices as instructed, or whether they admit to factoring in other considerations. Such extra information makes it possible to control for scenario adjustment ex post, to some extent, during estimation. These strategies for handling scenario adjustment can allow the researcher to simulate what an individual's willingness to pay (WTP) for the environmental good had they scrupulously followed the instructions in the survey.

Threatened and endangered species gather much attention in the literature given that conservation efforts may target these species. For example, Gong et al. (2020) ask respondents to consider potential conservation program efforts to support the endangered, Red-crowned Crane at the Yancheng National Wetland Nature Reserve and surrounding area in coastal China by funding a program designed to increase suitable habitat for the species (which overwinter at the reserve) and reduce pesticide use in the area. Stainback et al. (2020) estimate WTP for certain performance metrics of the Comprehensive Everglades Restoration Plan, including the number of wading bird species and the presence of the endangered Everglade snail kite, where these species are expected to benefit from proposed restoration efforts in the Florida Everglades.

Charismatic species are also often the focal point of conservation efforts. For example, Liu and Yang (2019) consider abundance of a single charismatic species, Black-Faced Spoonbills, but also include the number of other unspecified bird species at a single reserve site in Taiwan. Sehra and MacMillan (2021) select the Black-Crowned Night Heron as their illustrative example of a conservation-target bird species, to be protected by wildlife-friendly farming practices in rice paddies in Japan. In their study concerning ecological offsets, Rogers and Burton (2017) consider willingness-to-pay differences between more-abundant and less-abundant species among a set of migratory shorebirds. They focus specifically on two migratory shorebird species: Ruddy Turnstones and Eastern Curlews. Zambrano-Monserrate (2020) studies the value of habitat necessary to support a single iconic species, the Andean condor, mentioning the role of that species in the reduction of carrion (eliminating organic remains and contributing to their recycling, as well as helping the ecological succession of other scavenger species and "decomposers," thereby reducing the potential for infection in ecosystems).

In contrast, Garnett et al. (2018) purposely choose to feature non-charismatic species in their survey fielded to the Australian general public. Their choice experiments consider policies toward the Rufous Scrub-Bird (and its subspecies, the Scrubtit), as well as the Brown Thornbill (mainland form) and its subspecies the Brown Thornbill (Tasmanian form).[6] Clucas et al. (2015) focus on public programs that would be designed to support two types of common native urban birds—finches (songbirds described as "pleasing") and corvids (described as "displeasing")—in Berlin, Germany, and in Seattle, in the U.S. state of Washington. They emphasize seed dispersal and reduction of insect pests as some of the ecosystem-related benefits of these species.

Some studies concern wild birds but include other species as well. In their study concerning the Atacama desert, Cerda et al. (2018a) also include both well-known and lesser-known mammals, amphibians, reptiles, pollinating insects, succulents, woody shrubs, pristine landscapes and soil quality. Among bird species in the area, they focus on inland raptor species (scavengers and passerines) and shorebirds. Cerda et al. (2018b) seek to estimate WTP for the protection of animals, plants and soil, but they also explicitly consider the "provision of ecosystem services related to water resources," as well as tourism infrastructure.[7]

Valasiuk et al. (2018) motivate their choice tasks by emphasizing one species of bird, but other species are also dependent upon the fenland ecosystem they study, and Liu and Yang (2019) study a nature reserve dedicated to the support of one particular threatened and still-rare

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[6] Garnett et al. (2018) distinguish between a person's jurisdiction of residence and the location of the bird-related environmental good in question, using this difference to motivate their discussion of nonconsumptive "use" demand. Other demands may reflect only non-use values. Dobson et al. (2022), for example, could be argued to focus specifically on "non-use" demands by eliciting willingness-to-donate for overseas conservation areas.

[7] They decide against including the "scenic beauty" of the reserve, arguing that people already pay an entrance fee motivated by opportunities to admire scenery along hiking trails.

species, but their choice tasks also vary the number of other bird species present. Yao et al. (2014) and Yao et al. (2019) focused on iconic species (both the brown kiwi and the bush falcon, as well as three other types of organisms, including a fish, gecko, and a shrub species). Kolstoe et al. (2022) estimate WTP to go on a hike to a nature preserve in Hawai'i as a function of the chance of seeing endangered and threatened bird species. Krishna et al. (2019) focus on understanding species extraction from the wild, choosing different specific caged-bird species as representative for each combination of three underlying binary species attributes for which they seek to measure marginal values (rarity in the wild, trading frequency, and relative position of the species in terms of general price levels). They use four species groups, each containing eight distinct species (although two repetitions are necessary) so that their choice experiment involves 30 distinct named species.

Several groups of researchers focus on people's preferences over the attributes of a specific nature reserve or special ecosystem managed specifically to protect bird species. Some of the species in question are migratory, but others are resident populations. For example, Bennett et al. (2018) consider the Jiangsu-Yancheng Coastal Wetlands Rare Birds National Nature Reserve in China. Cerda et al. (2018a) study the Llanos de Challe National Park, a protected area of the Atacama Desert in northern Chile near Bolivia, while Cerda et al. (2018b) conduct their study with visitors to the Lircay National Reserve, a Mediterranean biodiversity hotspot in Chile. Liu and Yang (2019) focus on a Black-Faced Spoonbill refuge in the Qigu area of Taiwan. Kolstoe et al. (2022) focus on estimating WTP to go on a hike to Waikamoi Preserve, an ecologically unique nature preserve on the island of Maui in the state of Hawai'i managed by The Nature Conservancy of Hawai‘i and home to several endemic bird species. Czajkowski et al. (2021) are concerned with the Biebrza Marshes in Poland, one of the largest wildlife refuges in Europe. Xu and He (2022) ask respondents to consider the Nansha Wetland in Guangzhou, China. Petcharat et al. (2020) study potential programs designed to enhance ecosystem services from the Bang Kachao Green Area in southern Thailand where bird species richness is included to capture non-use value or existence value, given that the area attracts many native and migrant bird species.

Other choice experiments in the literature do not focus on a single refuge/reserve site but are still rather narrowly constrained to a particular geographic area. For example, Guimaraes et al. (2014) consider two wetland areas on Terceira Island in the Azores, located in the North Atlantic Ocean west of mainland Portugal. One of these two areas is a well-known birdwatching site where the main attraction is vagrant birds that have been diverted from their usual migratory routes due to storms.

Other choice experiments that concern wild birds focus on one type of ecosystem, in general, rather than a specific example of that type of ecosystem. For example, Yao et al. (2014) value planted forest management schemes that enhance populations of rare and protected native species in New Zealand (e.g., the brown kiwi), and Yao et al. (2019) extend that earlier study. Clucas et al. (2015) survey people in Berlin, Germany, and in Seattle, Washington (USA) about programs to change the abundance of common songbirds and corvid species, specifically in urban areas, where Berlin and Seattle are their two examples. Alternatively, Gatti et al. (2022) survey coffee drinkers in the U.S. to assess their willingness to pay (WTP) for ecolabels of several types, including a "Bird Friendly" certification. The coffee-growing countries in question do not appear to be specified in the survey, only farming practices for coffee-growing areas in general. Yamaura et al. (2016) focused on understanding WTP for higher proportions of broadleaved trees in conifer plantations to improve bird abundance given that these plantations have often replaced native forests and the monocrop negatively impacts biodiversity in an area.

Several contingent valuation studies have been conducted to study the value of protecting a particular species (e.g., Philippine Eagle, as in Labao et al. (2008)), a group of species viewable in a particular region (e.g., migratory shorebirds on the Delaware Bay, as in Myers et al. (2010); pintail ducks and waterfowl, as in Loomis et al. (2018)), iconic or flagship species (e.g., in Finland, as in Lundberg et al. (2019)), and threatened species (e.g., in Australia, as in Zander et al. (2014)). Other studies have been conducted to estimate the value of migratory bird protections during an outbreak of the bird flu (e.g., for Amsterdam, as in Brouwer et al. (2008)). In some cases, studies were done to estimate WTP for a particular site (e.g., mangrove preservation in Xuan Thuy National Park, Vietnam, as in Trung et al. (2020); WTP to preserve a Natura 2000 area in southeastern Spain, as in Zabala et al. (2022)). Some studies focused more broadly on a region (e.g., WTP for landscape and wildlife changes in the North Pennines, UK, as in Black et al. (2010); WTP to prevent species loss in the open sea around the Azores, including "birds", as in Ressurreicao et al. (2011)), or in some cases, multiple regions (e.g., WTP for marine species conservation, Azores, Portugal; Gulf of Gdansk, Poland; Isles of Scilly, UK, see Ressurreiçao et al. (2012)).

2.3 Valuing birding in general, birds or sites

Some studies focus on the demand by respondents specifically for birdwatching opportunities, so that the main ecosystem service provided to humans can be categorized as "cultural"—i.e., the enjoyment of opportunities to view wild birds. Implicitly, bird watching ("birding") as a recreational activity may confer additional enjoyment if the activity is social, or if people enjoy being out in nature. For example, Guimaraes et al. (2014) focus primarily on birdwatching, as to do Steven et al. (2017) and Xu and He (2022), without delving into the reasons why people enjoy birdwatching. In Guimaraes et al. (2014), birds are not one of the explicit attributes used in the choice experiments concerning infrastructure at two wetlands where birders commonly visit for the purpose of observing birds. However, these authors specifically mention opportunities to spot uncommon vagrant birds, blown off-course by storms, which make the two wetlands in question very popular for birdwatching.

Birding-related ecotourism or birdwatching in a specific location or region is an economic driver motivating several studies. For example, Veríssimo et al. (2009) consider tourists' WTP for tourism flagship species when visiting the islands of the Seychelles as to understand which species attributes (e.g., appearance, endemism, population size, special characteristics, number of days needed to see) may generate the most funds for conservation. Lee et al. (2010) estimate WTP for birdwatching-related ecotourism tours and interpretive services from an on-site survey at the Cheonsuman International Birdwatching Fair, South Korea). Faccioli et al. (2015) and Torres et al. (2017) both consider data from a choice experiment concerning wetland adaptation policies considered for the freshwater wetlands of S′Albufera, located in Mallorca (Spain). Both studies focus on the WTP of recreational benefits of wetland adaptation policies to climate change as the wetlands area attracts thousands of visitors annually, but Torres et al. (2017) incorporates uncertainty information.

Stemmer et al. (2022) use a choice experiment concerning destination choices in hypothetical birding trips, fielded to a convenience sample of visitors to an area containing an important island-based birding site in Norway. However, they note that while other researchers have used destination-specific bird attributes, they sought to design a study using attributes that "were potentially applicable to various Northern Hemisphere birding destinations." Their proposed birding destinations seem broadly representative, which is very helpful for transfer exercises. However, their sample is not necessarily representative of the preferences of the general population, or even of the population of birders, because their study participants were recruited either on-site, at a specific birding destination, or at a nearby lodging establishment. Their menu of site attributes might be transferable to other localities, but the preference parameters estimated using this sample may not necessarily be appropriate for the general population.

A couple of published studies ask respondents to choose among birding sites described generically, rather than associating the featured attributes with specific birding destinations. For example, Steven et al. (2017) ask whether a respondent would visit a site with given bird-related characteristics and cost "on their next trip," and fielded their choice-experiment survey with visitors at several birding sites in Australia, as well as a birding fair in the UK. The study of visiting birders in Norway by Stemmer et al. (2022), already mentioned above, asks respondents about hypothetical birding trips, and they also include scenery and "visitor facilitation" at the site as destination attributes, in addition to the site's bird-related attributes and the cost for each. Contingent valuation studies in this category include Frew et al. (2018), Haefele et al. (2019), Hanley et al. (2010), and Maldonado et al. (2018). Frew et al. (2018) compared the estimated WTP for tundra swans in eastern North Carolina across wildlife watchers, hunters and the general public and found that wildlife watchers followed by the hunters had the greatest WTP. Haefele et al. (2019) estimate the WTP of residents of Canada, the US, and Mexico for transborder migratory species conservation of the northern pintails. Hanley et al. (2010) estimate the WTP for different management alternatives concerning hen harriers, to support grouse abundance for sport-hunting in the autumn in the Scottish moorlands. Maldonado et al. (2018) estimate ecotourists' WTP for bird-watching destinations in Colombia.

2.4 Environmental damages

Changes in environmental quality may result from human-related impacts (e.g., oil spills) or infrastructure (e.g., buildings, wind turbines) which may negatively affect bird populations. For example, Liu et al. (2009) and Liu and Wirtz (2010) consider WTP for oil spill management practices in the German North Sea and one attribute in their choice experiment is how many eider ducks would avoid being impacted by the oil spill based on the management practice option. Liu et al. (2016) look at WTP for oil pollution clean-up in the Chinese Bohai Sea and include impacts on sea birds. Rogers and Burton (2017) explore tradeoffs that Australians are willing to make among programs that involve the use of environmental offsets to make up for lost habitat for two species of birds due to oil and gas development near a beach on the Kimberley coast of northwestern Australia.

Valasiuk et al. (2018) focus on the Zvaniec fen mire in Belarus, an open wet grassland region that is the almost-exclusive habitat of globally threatened wading birds, which have suffered because of widespread draining of these fens for intensive agricultural use. Kim et al. (2021) consider the tradeoffs people are willing to make concerning the potential construction of a new airport on an island in an archipelago off the south coast of South Korea (where they note that the area in question is "part of the East Asian-Australasian Flyway, where it serves as a stopover and wintering site for sea-crossing migratory birds, and as a habitat for resident birds").[8]

Kim et al. (2023) estimate WTP in South Korea for prevention of bird collisions with human-made structures through the use of special-purpose tape attached to soundproof walls on roads (both expressways and general roads), and buildings (both private and public). Peri et al. (2020) and Vuichard et al. (2022) both look at preferences for wind energy where one of the attributes of the choice experiment is the impact of wind turbines on birds. Peri et al. (2020) describe a study to understand preferences impacting public acceptance of wind turbines in northern Israel. They consider the distance of turbines from dwellings, land use, and shadow flickers (measured in hours per week), noise intensity and potential damage to bird populations.[9] Vuichard et al. (2022) explore which characteristics of wind energy projects tend to affect social acceptance of wind energy in Switzerland, Estonia and Ukraine, and consider ecological impacts (i.e., impacts on bird and bat populations), visual impact, ownership, distributional justice and procedural justice.

The studies mentioned above are choice experiments, but there are also some contingent valuation studies on this broad area. These more-specific studies also address human-induced impacts related to invasive species (e.g., biodiversity loss due to invasive species in the Seychelles, see Mwebaze et al. (2010)) and marine plastic pollution (e.g., in the European Artic, see Abate et al. (2020)).

2.5 Conservation and payment for ecosystem services provided by birds

In some cases, it is important to consider the different ecosystems that serve as habitat for bird species at different times of the year, and also the preferences of the different human populations that share these other habitats. Vogdrup-Schmidt et al. (2019) consider the WTP of Dutch households to support transnational conservation efforts of open land habitats, which have been identified as some of the most endangered habitats in the European Union and support the Common Crane and Golden Plover (regional bird migrant species) as well as the Montagu's Harrier (a long-distance migrant bird species). They asked their respondents, all of whom lived in Denmark, to consider programs that would involve changes in the extent in open-land habitats in Denmark and in the Netherlands. Habitat in the Netherlands represents a credible substitute for similar habitats in Denmark, given the proximity of the two countries. They find that respondents in Denmark are willing to pay for conservation efforts in the Netherlands, and their WTP also depends on the costs to be borne by residents of the Netherlands.

Alternatively, Sharma and Kreye (2022) explore the social value of bird conservation on private forest lands in Pennsylvania. In that region, most forests are privately owned and forest habitat is an important landscape for migratory birds. In the midwestern US, grasslands are an important landscape, supporting many resident and migratory bird species, and Dissanayake and Ando (2014) and Li and Ando (2023) both investigate the WTP for grassland restoration in the

[8] Kim et al. (2021) survey Korean people who have visited at least one national park, anywhere in Korea, over the previous five years. They ask about a proposed plan to build an airport on an island where bird habitat would be adversely impacted by the project. While this audience may never yet have visited the island with the proposed airport, they may wish to visit it in the future. Thus, the type of demand in question may consist largely of "option" demand or "existence" demand. Notably, they do not include island residents in their sample, so the "use" component of the demand they estimate may be negligible.

[9] We note, however, that there may be some issues with the choice of estimating specification reported in Peri et al. (2020). It is unconventional.

region. Dissanayake and Ando (2014) focus on the type of grassland restoration, while Li and Ando (2023) find that an individual's early exposure to nature impacts their willingness to pay for the restoration of grassland area near them. Alternatively, Zambrano-Monserrate (2020) considers habitat for one specific iconic species, the Andean condor. This species' range is from northern Colombia and western Venezuela through the Andes south to Tierra del Fuego in Argentina and Chile. However, this particular study focuses on condor habitat only in Ecuador. Garnett et al. (2018) consider policies to help the adaptation to climate change of four non-charismatic bird species (and subspecies) on the Australian mainland and in Tasmania. Unfortunately, however, they do not include a cost attribute, so their tradeoff estimates do not permit WTP inferences.

A few choice experiments in our inventory go into some detail, enumerating for their respondents the various ecological roles of wild birds in a specific ecosystem that people might value indirectly through farming practices used to produce a good. Ecolabeling provides information to potential consumers about such practices. For example, Gatti et al. (2022) does not focus on specific species of birds, just the "bird-friendly" biodiversity certification attribute for the different coffee brands among which their respondents are asked to choose. Salazar-Ordóñez et al. (2021) investigate willingness to accept (WTA) compensation, by olive oil farmers in Andalusia in southern Spain, to adopt environmentally friendly farming practices in their orchards, where positive impacts to bird species is conveyed through the use of bird images on the labels of olive oil bottles. Sehra and MacMillan (2021) likewise explore WTP for rice that has been grown with "wildlife-friendly farming" (WFF) certification in two types of rice-growing landscapes in Japan.

Studies that focus on wildlife-friendly farming practices often mention the beneficial effects of different farming techniques for wild bird populations, but not all of them specifically mention that healthier bird populations can reciprocally benefit farmers. For example, Bennett et al. (2018) use choice experiments with farmers near a coastal rare-bird nature reserve to assess these households' willingness to accept compensation in programs to reduce pesticides that harm wetland birds. In particular, they are concerned with Red-Crowned Cranes. Valasiuk et al. (2018) likewise focus specifically on the Aquatic Warbler in one fenland area of Belarus. Sehra and MacMillan (2021) focus on wildlife-friendly farming and its contributions to biodiversity, characterized as the presence of animal species, including frogs, birds, or fish. Sharma and Kreye (2022) focus on programs for habitat conservation on private lands and highlight specifically seed dispersal, pollination, and pest control as benefits.

Two other agriculture-related studies, Bennett et al. (2018) and Czajkowski et al. (2021), address the willingness to accept, by farmers, of compensation contracts that would oblige them to adopt bird-friendly agricultural practices. Indirectly, these farmers must take into account the likely net benefit in terms of the price they can charge for their product if these ecologically preferable practices are known to their consumers (plus the program's compensation) against the cost of implementing these different practices. Bennett et al. (2018) ask rural households around the Jiangsu-Yanchenge Coastal Wetlands Rare Birds National Nature Reserve in China, an ecological important site for 15-18 percent of the world's Red Crowned Cranes, about their preferences for compensation (WTA) to participate in environmental-friendly management practices to reduce negative impacts of farming from pesticide use on birds. They explore different options that could be included in the contract, including the length of the contract and whether the contract would involve a penalty if they left the program early.

Czajkowski et al. (2021), in the training module of their survey concerning farming practices, ask their respondents specifically about the Aquatic warbler and the Ruff (two species considered to be symbols for the area), the Black-tailed godwit and the Eurasian curlew (protected by existing agri-environmental programs), as well as the Northern lapwing and the Eurasian wigeon (both of which are simply popular birds). But the magnitudes of the beneficial effects of the proposed farming practices on these bird species are only implicit across the choice tasks their respondents are asked to consider. The authors do point out that some other bird species in the area tend to be undesirable from a farmer's perspective, since farmers desire compensation for the loss of crops due to protected farmland birds (e.g., Greylag geese and Cranes).

Other approaches, including contingent valuation and contingent behavior methods, have also been used to value specific bird-supporting ecosystems. Cuyno et al. (2001) use contingent valuation to estimate WTP to reduce risks to birds and other species from pesticides in Luzon, Philippines. De Wit et al. (2017) use contingent valuation to estimate WTP for the lagoons in the Palavas complex in southern France (which includes marine and freshwater ecosystems). Caula et al. (2009) use contingent valuation to estimate the WTP for green spaces and their importance for avifauna conservation in Montpellier, France. Hynes and Hanley (2009) use the contingent valuation approach to estimate farmers' WTP to conserve an endangered farmland bird species, the corncrake, in Ireland. Tisdell et al. (2007) employ an expenditure-allocation version of contingent valuation to assess support for conservation of different species in Australia (including 10 bird species, and 14 other species of mammals and reptiles). They focus on endangerment versus likeability as determinants of WTP for wildlife conservation. Dupraz et al. (2003) collect contingent behavior data and estimate farmers' willingness to accept compensation for participating in an agri-environmental program in the Wallon region of Belgium.

2.6 Other cultural ecosystem services

Birdwatching as a hobby can be a deliberate form of engagement with wild birds. For "listers" in the birdwatching community, this pastime can even become an intensely competitive sport. Birdwatching may thus be considered as distinct from other more-passive, incidental, ways in which humans may benefit from the presence of wild birds in their surroundings. Besides supporting birdwatching as a form of recreation, Boeri et al. (2020) itemize some of the non-material cultural benefits of biodiversity, including spiritual enrichment, cognitive development, reflection, and aesthetic experiences. These authors cite others who have mentioned links between biodiversity and human wellbeing, measured as psychological restoration, improved physiological health and better social relations. Holmes (2020), however, points out that some ecosystem service benefits, such as spiritual benefits, may not be appropriate to monetize.

3 Survey Design: Mode, estimating sample size, and sample type

In the development of any choice-experiment survey, researchers must make several decisions about how the survey will be structured and implemented. It is necessary to choose a survey mode (e.g., face-to-face, mail, telephone or online), and whether to use self-administered surveys (where the respondent completes the survey on their own) or interviewer-administered surveys. The researcher must plan specific in-the-field dates, decide upon the number of contacts or invitations, the targeted sample sizes, and whether to use a probability-based or non-probability-based sample (e.g., quota sampling, or merely some "sample of convenience") (see Champ et al. (2017), Chapter 3 – Collecting Nonmarket Valuation Data).

The estimates produced by a survey-based choice experiment are relevant for the population that the estimating sample represents, and this may not be the same as the general population of interest. Respondents may be people who are intercepted at a particular site (e.g., Clucas et al. (2015)), or they may be selected at random from a database of street addresses, email addresses, or telephone numbers, or they may be recruited by telephone through random-digit-dialing. In recent years, however, it has become much more common/expedient for researchers to use standing online consumer panels maintained by survey research firms (e.g., Dobson et al. (2022), Gatti et al. (2022), Kim et al. (2021), Rogers and Burton (2017)).

Many choice-experiment surveys targeting the general population are now implemented primarily in an online format using standing panels (or in some cases, using address-based mail samples with a so-called "push-to-web" option for respondents). With high rates of penetration for smartphones, and with survey formats optimized for small-screen delivery, digital-only surveys have become very attractive. As researchers consider their planned survey mode and its implications for who will respond to their survey, they may want to consider that many potential respondents may not have "anytime" access to a large-screen personal computer or tablet, and it has become more important to plan for small-screen viewing of choice tasks.

Whatever survey mode is used, representative samples are very important, especially when the researcher is seeking to estimate values that will be used in policymaking. Convenience samples can be used relatively safely if the study's objective is merely to demonstrate, for at least some part of the population, that certain attributes in a choice task are important and have either a positive or negative effect on choices. However, convenience samples are not typically representative of the population of interest, so inferences based on convenience sample are often not suitable to be scaled from the estimating sample to the general population. To salvage a convenience sample, it may sometimes be possible to collect data on factors that determine each respondent's propensity to appear in the estimating sample, whereupon there may be some hope that sample-selection correction methods may be viable. But most sample-selection correction methods require comparable data on these factors for all non-respondents, as well. More on this later.

In the next subsections, we review some of the studies in our inventory to discuss survey contact modes and sample designs.

3.1 Online survey panel

Numerous survey research firms now maintain standing consumer panels—large groups of people who have opted-in to complete some number of surveys per month in exchange for (typically modest) amounts of compensation. These firms can typically deliver a sample with marginal distributions of respondent characteristics that match the corresponding marginal distributions in the population of interest. It is still important, however, for researchers to consider potential sources of systematic selection, so these can be minimized (e.g., coverage error of the study population, nonresponse error, etc., see Champ et al. (2017)). At a minimum, concerns about the potential for non-response bias dictate that researchers report the number of completed surveys as a fraction of *total invitations distributed*, not just the number of completed surveys as a fraction of completed-plus-incomplete surveys.

Typically, it is necessary to assume that the standing consumer panel maintained by a survey research firm is, itself, representative of the general population, although it is always worth asking (and reporting) how the company recruits their panelists. Unsurprisingly, high-quality panels are more expensive to use. Selection on some characteristic that is truly independent of people's preferences for the good to be valued via the survey can sometimes be innocuous (i.e., when the distribution of WTP in the selected sample remains essentially identical to the distribution of WTP in the population). However, selection in terms of panelist characteristics that are systematically related to preferences concerning the non-market good in question are a concern (i.e., selection based on the individual's interest in the survey topic). As another example, survey research samples must often be restricted to persons aged 18 and above (to avoid having to get Institutional Review Board approval for the participation of minors in a survey).[10]

Several of the papers we review in this chapter name the specific company whose panelists they have used, but others do not. Some mention the number of invitations. Best practice also includes reporting the time interval during which the survey was in the field, and the size of the financial incentive provided. For example, Rogers and Burton (2017) use an online survey distributed by "a market research company," fielded during October-November 2014, to a sample of 1371 respondents stratified by age, gender and location. Garnett et al. (2018) use an online survey fielded to a sample recruited from a panel maintained by MyOpinions PermissionCorp, where the active panel includes about 300,000 members and is managed for research only, according to governance by marketing research industry bodies. They invited 7,816 people during September-October of 2014 and received 1,421 responses and 1,119 completed questionnaires.

Kim et al. (2021) collect their data via an online survey using a panel recruited by a survey research firm in Seoul. During November and December of 2017, they issued almost 13,000 invitations and 2,200 individuals were willing to participate. They employed quotas for age, gender and regions, and 158 incomplete responses were taken into account, and the survey closed when 1000 eligible respondents completed the questionnaire. Dobson et al. (2022) recruited their 852 UK-based respondents via an online research platform (Prolific) in May 2019. Gatti et al. (2022) use a Qualtrics online survey of 774 US coffee drinkers aged 18 or older, fielded in December of 2020. Participants received a financial incentive. There appears to be no discussion of the total number of invitations issued, or whether quotas that may have been used. With ten choices by each respondent, their sample yields 7,740 total choices for analysis.

3.2 Online delivery, unspecified

For other online surveys, the party actually fielding the survey was not immediately apparent from the published paper (but may be mentioned in the paper's supplementary documentation, not all of which we were able to access). Yao et al. (2019) follow up on an earlier survey (which used a combination of modes) using an online survey between January and June of 2015, where 1,356 respondents completed the new survey. Zambrano-Monserrate (2020) uses an online survey to respondents over 18 years old and able to make financial decisions, fielded between

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[10] With no direct preference information for people younger than 18, the study cannot make predictions about their preferences simply by modeling the preferences of the adults in the sample as a function of age, and then extrapolating the model to younger age groups. It is important that any inferences from such a study be flagged as applying, at best, to "the general population over 18."

August 10, 2019, and August 30, 2019. After elimination of surveys with incomplete or inconsistent responses (with no discussion in the paper of the exclusion criteria), 825 valid questionnaires were retained for analysis. Stemmer et al. (2022) conduct an online survey, pilot-tested in English and Norwegian. The final survey was sent to 559 email addresses during March and April 2018 with versions available in four languages. Adjusting for undeliverables, 521 birders received an invitation and the analysis based on choices made by 205 respondents having complete data. Sharma and Kreye (2022) field a statewide "web survey" to Pennsylvanians. The actual dates of fielding the survey are not immediately apparent.

3.3 Face-to-face surveys

Face-to-face is a traditional mode of survey delivery that has a long history as a means of gathering data on the preferences during household visits, or the preferences of members of a given user group (often by conducting surveys on-site). The main disadvantage of face-to-face surveys is the potential for individual interviewer effects, where the gender, appearance or demeanor of the interviewer may have some unrecorded influence on respondent's survey answers or their response propensities. Despite careful training, different interviewers may also provide different types or amounts of clarifying information to respondents. Gong et al. (2020), Kim et al. (2023) and Veríssimo et al. (2009), for example, all use face-to-face interviews.

3.3.1 Household surveys

Clucas et al. (2015) use face-to-face interviews conducted at the respondent's residence—in this case of 460 residents across ten study sites in Berlin from August 2008 to December 2008, and 209 residents in eight study sites in Seattle from October 2009 to February 2010. Valasiuk et al. (2018) administered a face-to-face survey with a sample of the Belarusian population, with 270 completed interviews conducted at respondents' homes in January of 2010. The estimating sample included 206 respondents with "valid questionnaires." Krishna et al. (2019) use computer-assisted personal interviews employing the software Surveybe, after translating their survey into the local language (Bahasa Indonesia). Their survey was in the field between February and May of 2016 in Jambi City. Their sample is limited to current or recent owners of caged birds. They contacted 504 households, and report 5,812 "observations."[11] Czajkowski et al. (2021) used computer-assisted personal interviews (CAPI) with 463 farmers, conducted by agricultural advisors who normally work in the area. The survey was in the field during June-August of 2017 and in March 2018. They report using a stratified quota-sampling method.

3.3.2 On-site intercept surveys

On-site intercept surveys take members of the research team (or hired assistants) to some location where they can make contact with a variety of people who have demonstrated by their behavior that they are interested in the ecosystem services supported at that destination. For example, Steven et al. (2017) intercept respondents at Australian birding sites and at a UK birding fair between May 2013 and November 2014 and collect 283 complete responses. They

[11] We note that Stata refers to "alternatives" as observations. Each questionnaire in this study contains only 8 choice tasks, so it seems more likely that their 504 respondents (times 8 choice) face a total of no more than 4032 total choices, where perhaps not all respondents completed all the choices offered to them.

identify birders in the Australian samples by the equipment they are carrying or through casual greetings. Participants at the UK birding fair are assumed to be birders. A study by Cerda et al. (2018a) surveys roughly 500 adult income-earning Chilean visitors to a National Park between January and March 2013. Cerda et al. (2018b) use about 400 face-to-face interviews with adult income-earning Chilean citizens visiting a reserve during 2013. Liu and Yang (2019) conduct an on-site intercept survey of visitors to two of three birdwatching pavilions in a Black-Faced Spoonbill reserve in Taiwan. Their survey was in the field during March and April of 2013 and they collected 434 completed questionnaires. They used a formal algorithm to select their first contact systematically. Then they approached every third person after that. Potential respondents were informed that the survey's purpose is "for better managing the coastal wetland."

On-site surveys, however, tend to suffer from systematic selection in that anyone who is interviewed has already decided to visit the site in question. Furthermore, it can be difficult to adjust for the differing odds of interviewing any specific person among site visitors (even with an "every third person" type of approach). For frequent visitors, the odds of being interviewed are higher than those for people who visit rarely, so the preferences of frequent visitors will be over-represented in the sample. Also, without any responses from people who do not already visit the site, it is difficult to say much about the distribution of preferences of the general population.

3.3.3 Other

In other cases, researchers may opt to use different sampling strategies. For example, Guimaraes et al. (2014) survey both on-site birders (during one birding season in October and November of 2011), and off-site birders who have visited their study area in the previous season. Off-site birders were located through "blogs, Facebook, and specialized websites." The off-site birders took a mixed-mode survey with an identical electronic questionnaire that was self-administered. An on-site interviewer assisted the respondent for the in-person survey, and an interviewer assisted the respondent by phone/VoIP for the off-site surveys.

On-site samples must typically be considered samples of convenience. For example, Sehra and MacMillan (2021) collect responses from a convenience sample of 231 people at a selection of intercept locations (farmers' markets, public parks, train stations and university campuses) during April-June 2019, with 1375 choice observations in their data.

4 Survey Design – Formal Choice Design Criteria

4.1 Choice set structure, elicitation method and choices per respondent

The complexity of a choice set, if too great, can lead to non-response. Alternatively, the respondent may start to rely on heuristics in selecting their preferred alternative. If a choice set is too complex, involving either too many alternatives or too many attributes (or both), some respondents are likely to ignore some attributes, focusing only on those which are most salient to them. For more-complex choice sets, some researchers follow up with specific questions about which attributes the respondent may have mostly ignored in their decisions.

In the Supplementary Materials associated with this chapter, we have also assembled a large selection of choice set examples, corresponding to many of the studies mentioned in this review. The different surveys range widely in the number of these choice tasks they present to respondents, with counts ranging up to 16 in some cases, but with the modal number being more like six choice tasks (with details provided in the comprehensive spreadsheet also included in our Supplementary Materials). In the subsections to follow, we categorize the studies in our inventory according to the structure of their choice sets.

4.1.1 One substantive alternative and the status quo

Pairwise choice tasks, often called "referendum" choice tasks, have desirable properties in terms of incentive compatibility (Champ et al. (2017), Johnston et al. (2017)). The simplest pairwise choice tasks—if the non-cost attributes of the good in question are the same for each choice and for everyone in the sample—constitute what is known as "contingent valuation" tasks. Among the studies we discuss in the body of this chapter, Zambrano-Monserrate (2020) represents one illustrative example of a referendum contingent valuation method, rather than a full choice experiment. Respondents were first asked if they were willing to pay, in general, for a single "public (hypothetical) program to save the Andean condor." If they answered in the affirmative, respondents were then asked about whether they would pay a specific "bid" amount. Each respondent was asked about just a single randomly assigned bid chosen from six payment levels.[12]

Typically, a choice task is not called a choice experiment unless there are multiple attributes, besides the cost attribute, that vary across choices and/or across respondents. In a choice experiment, it is possible to calculate marginal WTP measures for each attribute. In contingent valuation, if the non-cost attributes of the non-market good are *unchanged* across both choice tasks and respondents, so that exactly one specific bundle of attributes is being valued in the study, then it is not possible to tease out separate marginal WTP estimates for any of these attributes, only a value for the bundle as a whole.

Several papers in our inventory, however, use binary "referendum" choices between one program and the status quo, but vary the specific program/policy under consideration across choice tasks (although not within a choice task), or across respondents. For example, Cerda et al. (2018a) use choice sets consisting of pairwise comparisons of the alternative park management situations (64 in total), randomly blocked into eight questionnaire versions with eight choice sets each. Kolstoe et al. (2022) use choice sets consisting of pairwise comparison of different potential hike program compared to the current status quo option (36 in total), block into six choice sets based on an optimal D-efficient design. Sharma and Kreye (2022) use choice experiments that present proposed programs one at a time in a dichotomous choice (referendum) format, where respondents either accept or reject that particular program at a specified price. There were eight scenarios or proposed programs.[13]

[12] Payment card responses can be estimated using software for choice experiments, if necessary, as a set of yes/no binary responses to each of the thresholds listed on the payment card (see Cameron et al. (2002). However, ad hoc interval-data regressions methods are typically employed, without relying on the utility-theoretic framework that underlies the analysis of data from choice experiments.

[13] It seems that each respondent in the survey was asked about all eight proposed programs, although this is not entirely clear in the main paper.

4.1.2 Two substantive alternatives and the status quo

In their study of infrastructure options for two wetland areas that support bird populations, Guimaraes et al. (2014) ask respondents to choose their favorite among three alternatives, where one of these alternatives is always the status quo. Visual representations were used to convey attribute levels. Yao et al. (2014), in their study of five threatened plant/animal species in New Zealand, give each respondent nine choice tasks, each consisting of two substantive alternatives versus current conditions. Yao et al. (2019) appear to have used the same choice structure in their follow-up study. In their choice experiment concerning two pairs of related species in mainland Australia and Tasmania, Garnett et al. (2018) give their respondents two substantive management options for climate change adaptation and a status quo option.

In their study of birds as pets, Krishna et al. (2019) use choice sets where each choice set contains two specific birds of different species, plus an option not to purchase either bird. They focus on a set of attributes of wild bird species as pets, and "brand" each potential pet bird with a specific species name, where this species represents different combination of the three basic bird attributes (rarity, trading frequency, and price). All choices included a no-purchase alternative, and each respondent considered eight choice sets.

Kim et al. (2021) use choice sets with two alternatives policies concerning the construction of an airport that will affect bird habitat and a no-airport option, and each respondent was asked to consider four choice sets. Gatti et al. (2022) ask each respondent ten choice questions, where each choice appears to have been between two substantive alternatives for certification of coffee-farming practices in the purchase of coffee, and a no-buy option, although they seem to have made the various certification options mutually exclusive. Stemmer et al. (2022) asked their respondents to choose between two different birding destination options and a no-trip option. Each survey version had a block of four randomly assigned choice sets.

4.1.3 Three or more alternatives and the status quo

Fewer studies use three or more substantive alternatives and the status quo, typically due to concerns about the cognitive burden imposed by more-complex choice tasks, as well as issues relating to consequentiality of the choice (Johnston et al. (2017)). However, a choice context with multiple alternatives does make it possible, in principle, to glean much more information about preferences from each choice task, especially if respondents are able to rank the alternatives (either completely, or by identifying just the best and worst options).

Rogers and Burton (2017) study people's preferences for environmental offsets when bird populations are threatened by development. They use choice scenarios with three policy alternatives and an opt-out alternative. Steven et al. (2017) use choice cards that present respondents with a choice among three potential hypothetical birding destinations and the status quo (no visit). Each person considered six different choice cards, drawn from a full set of 18 cards blocked into three sets of six. In their study of tourists' WTP for additional species of rare birds at a wetland reserve in Guangdong, China, Xu and He (2022) use choice tasks where each choice set was composed of three hypothetical scenarios for attributes of the wetland and a status quo option. However, each survey instrument included just one choice set.

In their study concerning preferences for limits on farming practices and conservation areas in a fenland area of Belarus, Valasiuk et al. (2018) use a survey where each respondent made 16 choices, each one including a status quo alternative and three substantive program alternatives. Respondents were asked to pick their most-preferred and least-preferred alternatives (a "best/worst" approach), rather than just their most-preferred option. Czajkowski et al. (2021) survey farmers and use choice sets with three types of contracts involving compensation for bird-friendly farming practices and a no-contract option, and they ask respondents to completely rank these alternatives, including the "no contract" option, from most-preferred to least-preferred. They present each respondent with up to six choice situations regarding arable land and livestock reduction, and up to three choices regarding peatlands and meadows, provided these programs apply to their farm.

Choice sets that involve too many alternatives and/or too many attributes per alternative can strain the cognitive capacity of respondents, especially if respondents are impatient to complete the survey. Nevertheless, Liu and Yang (2019) offered their respondents choices between four substantive alternatives and "none of these." Each respondent was asked to consider two choice tasks. In studies where the choice tasks are especially complex, it is prudent to pay particular attention to attrition and the possibility of respondents having resorted to heuristics (e.g., paying attention to only a subset of the information in the choice task).

4.1.4 The status quo alternative

It is generally important for respondents to be offered the option just to keep what they have now, rather than being forced (hypothetically) to pay money to have some other option than what they have at present (which can, in real life, continue to be enjoyed at no extra cost). Two of the papers in our inventory ask respondents to make "forced choices" between alternatives that do not include the status quo (or a no-purchase or no-trip option, in these cases). First, Sehra and MacMillan (2021) provide each respondent with six choice sets, each including three different types of rice: two are hypothetical wildlife-friendly rice products and one is a non-wildlife friendly product. They do not appear to have used a no-purchase option. Their numeraire good is a non-wildlife product with no species, non-organic, non-special-origin landscape and a price of 2000 JPY, but still involves the purchase of the default type of rice. The choice is thus conditional on the consumer buying at least some 5-kg bag of rice. However, such a forced-choice scenario may truly be plausible in this context, since almost everyone in Japan is likely to buy supplies of rice at regular intervals anyway.

A different rationale for having no status quo (opt-out) option is employed by Dobson et al. (2022). They use choice experiments involving a forced choice between visits to two hypothetical conservation areas. They do not include a "neither" option because they want to prevent respondents "from earning their reward without weighing up the alternatives." They mention other studies where researchers have reported the respondents disproportionately choose "neither" when faced with complex choices. It is not entirely clear that the benefits of a forced choice outweigh the risk of scenario rejection by respondents. They make their stated choices "conditional on having to pick one of these alternatives" whereas, in reality, the status quo is always available to them. It is therefore risky to attempt to estimate population WTP for any of the alternatives, because it is not possible to reflect whether people would choose any alternative over none.

5 Design of the Choice Experiment

Choice experiments are distinguished from contingent valuation surveys in that more attributes are varied across alternatives besides just the cost. Choice experiments may be unnecessary if only one "bundle" of attributes truly needs to be valued. However, variation in attribute levels is what permits the researcher to identify distinct marginal utilities associated with each attribute. These distinct marginal utilities permit the estimated model to be used to value any combination of attributes within the range of levels for the attributes used in the study, including new combinations that did not appear in any of the hypothetical choice tasks posed to respondents.[14]

5.1 Generality vs. specificity of program/policy attributes

In the general literature on choice experiments, as applied in market research contexts, researchers must decide whether to offer respondents choices between "branded" or "unbranded" alternatives (Louviere (2001)). If the consumer product is given a "brand name," that name may convey a lot of information to respondents who have had prior subjective experiences with that company's products or who are aware of the company's reputation (e.g., quality or reliability). In addition to the set of explicit attributes ascribed to the product in question (e.g., size, color, weight), these brand effects may influence the respondent's choice. The estimating specification for a branded choice experiment will thus typically include an indicator variable for each brand. If the product is unbranded (think "Brand X"), then the respondent must make their choice based solely on the explicitly stated attributes of the product. If a market research project wishes to predict demand for a *new* product from a new company, a branded choice experiment will be less useful, because the "brand effect" for the new company will be unknown. If the choice experiment is designed to include both branded and unbranded options, however, then the estimated model may be able to quantify the (potential) decrement to WTP that is associated with a brand that is unknown to the consumer.

By analogy, a particular study intended to value wild birds may focus on one species. But a choice experiment that concerns only one species can be used to predict the likely WTP only for that particular species. If proposed policies or programs that affect a species of primary interest can be embedded among policies/programs that affect other "unbranded/unnamed" species of birds with varying mixes of the same set of attributes (e.g., size, color, guild, threatened/endangered status, etc.), then the estimated model could potentially be used to derive estimates of WTP for programs that benefit any species that could be adequately described using the same types of attributes.

In some cases, researchers have selected representative named species which span a set of implicit attributes that are not listed specifically in the choice tasks presented to respondents. Krishna et al. (2019) use 30 named species of wild birds in their study of caged-bird demand in Sumatra. Some of the attributes used in their model were explicit in the choice tasks (i.e., rarity in the wild, bird origin, and trainability for singing). Other attributes in their model were not explicit in the choice tasks, but differed across these 30 species (specifically, the trading frequency for that species, and the relative price of that species). These authors did not include thirty different species indicators in their models (i.e., they used no "brand effects"), thus forcing

[14] Still, if only one common *set* of marginal utilities, across all respondents, is estimated by the model, there will be exactly one common WTP (i.e., point estimate and associated interval estimate) for any specific combination of attributes.

all differences in preferences to be associated with differences in the explicit and implicit species attributes.

Some studies, unfortunately for their usefulness for benefits-function transfers, use relative or qualitative descriptions of quantities. For example, Kim et al. (2021) use a choice experiment where the key attribute levels are described as high-medium-low without specific quantities, either as relative amounts or with respect to the status quo. It is not clear how each respondent interpreted a "medium" or "high" reduction in the number of birds. Alternatively, Dallimer et al. (2014) include some information about the number of different species of birds as an attribute of the different alternative in their choice experiment, but the attribute levels are given simply as "Lots more species," or "Some more species."[15]

5.2 Examples of bird-related attributes employed in different choice experiments

The choice of which bird-related attributes to include in a choice experiment reflects the specific goals of the study in question. Studies related to tourism/recreation may seek to value wild birds directly, whereas studies related to conservation may value them indirectly.

As noted above, some studies in our inventory focus their choice tasks on just one, or just a few, specific species of birds. Some of these species, in different regions, have included the following: North America's gamebird species, including partridge, pheasant and quail, and specifically Nenslow's Sparrow (Ahearn et al. (2006)); the UK's Hen Harriers and Golden Eagles (Hanley et al. (2010)); Spain's Red-legged Partridge (Delibes-Mateos et al. (2014)); Finland's Capercaillie (Juutinen et al. (2014), Juutinen et al. (2017)); New Zealand's Brown Kiwi and Bush Falcon (Yao et al. (2014), Yao et al. (2019)); Vietnam's Red-headed (Sarus) Cranes (Khai and Yabe (2015)); Australia's Eastern Curlews and Ruddy Turnstones (Burton et al. (2017), Rogers and Burton (2017)); Australia's Brown Thornbill, Scrubtit, and Rufous Scrub-bird (Garnett et al. (2018)); the UK's House Sparrows, Blackbirds, Woodpigeons, Blue Tits, Robins, and Bullfinches (Brock et al. (2017)); Taiwan's Black-faced Spoonbill (Liu and Yang (2019)), and Ecuador's Andean condors (Zambrano-Monserrate (2020)).

Several studies do not go so far as to focus on specific species, but still restrict their choice tasks to scenarios that involve just certain categories or guilds of birds. For example, Clucas et al. (2015) limit their choice tasks to scenarios about urban birds which are either songbirds or corvids. Othman et al. (2004) concentrate on migratory birds, and MacDonald et al. (2011) consider waterbirds. Cerda et al. (2018a) distinguish between scavenger raptors, passerine raptors, and shorebirds. Other researchers focus on rare or threatened species (e.g., Steven et al. (2017), Krishna et al. (2019), De Salvo et al. (2022), Dobson et al. (2022), Sharma and Kreye (2022), Xu and He (2022))

Other types of studies describe wild birds more generally. Some include attributes such as the number of birds protected (e.g., Kim et al. (2023)). Others describe whether damage to bird habitats will cause small, medium, or large changes in the overall abundance of birds (e.g., Kim et al. (2021)).

[15] One other concern for benefit-function transfer applications is the lack of clarity about whether respondents differentiated between species richness and abundance. For example, people might assume that average abundance per species remains constant, so that more species would mean more total birds. But people might instead assume that overall abundance of birds would be held constant. Then a scenario with "Lots more species" means that the abundance of each species would have to diminish. It is risky to leave respondents to assume whatever they like about other important attributes that are also likely to change.

A growing number of studies seek to value biodiversity in bird populations. For example, a significant choice experiment conducted by Boeri et al. (2020) explores respondents' attention to alternative measures of biodiversity among birds, including the number of different types of birds; the number of individual birds; the likelihood of seeing a rare or unusual type of bird; and the probability of seeing a "wildlife spectacle" such as thousands of birds in one flock. Other studies focus solely on species richness as a measure of biodiversity among wild birds (e.g., Naidoo and Adamowicz (2005), Dallimer et al. (2014), Steven et al. (2017), Liu and Yang (2019), Jaung et al. (2020), De Salvo et al. (2022), Stemmer et al. (2022), Tanaka et al. (2022)).[16]

Several choice-experiment studies concern so-called agri-environmental schemes (AES) and motivate these programs by explaining how they will help bird populations. However, the effects of these programs on wild birds is not included among the explicit attributes of the different programs, and birds themselves are valued only indirectly in these studies (e.g., see Bennett et al. (2018), Valasiuk et al. (2018), Czajkowski et al. (2021), Buschmann et al. (2023), Collas and Balmford (2023), Collas et al. (2023), Fockaert et al. (2023), and Thiermann et al. (2023).

Alternatively, some choice experiments in our inventory have at least one of the attributes of the alternatives in each choice task be something that involves wild birds. For example, some studies include an attribute for whether "birds" are a species category that will be helped by the program (e.g., Kataria (2009), Cerda et al. (2018b), Lévesque et al. (2022)). Other studies involve eco-labeling programs, where some agricultural products among a set of alternatives are grown under "bird-friendly" conditions. These products have included rice (e.g., Sehra and MacMillan (2021), Mameno et al. (2023)), and coffee (e.g., Gatti et al. (2022)).

5.3 Design efficiency

Stated preference questions require some "design" for the mixes of attribute levels to be presented to respondents. In contingent valuation papers, with bid distributions only, researchers focus on pre-testing the different bid designs and then randomly assign the bid values.[17] For choice experiments, where other attributes besides costs will differ across alternatives in each choice task, researchers typically employ some set of formal criteria for efficient design.[18] Researchers typically use one of a limited number of choice-set design software packages, such as those offered in NGENE, SAS, AlgDesign (an R algorithm) or dcreate (a STATA algorithm).[19] In some cases, researchers cite no particular software package, but reference other experts (see the Appendix).

[16] The choice experiment by Khai and Yabe (2015) has indicators for either a 50% or 100% increase in "biodiversity," but the exact concept of biodiversity does not seem to be made explicit.

[17] For example, Clucas et al. (2015) do not use multi-alternative choice experiments, but double-bounded dichotomous choice contingent valuation questions. They used pre-tests to design the different bid amounts. Zambrano-Monserrate (2020) uses only one generic policy and assigns six different bid values randomly in his straightforward contingent valuation study. Given that this study does not constitute a choice experiment in the usual sense, the mix of attributes (other than the cost attribute) remains constant across respondents (and across choice tasks for any given respondent).

[18] Note that a couple of papers do not settle for optimizing just one type of efficiency, but conduct their surveys in waves, rotating through different available efficiency criteria in an effort to take advantage of the benefits of all these different criteria.

[19] The Ngene package for designing choice sets appears to be the most commonly used among named packages for the set of papers we inventory here.

Design efficiency can be important. These algorithms maximize the useful information obtained from any given sample size or allow a target level of estimation efficiency to be achieved from the smallest (and therefore cheapest) sample. However, there are some limitations to consider when seeking to maximize design efficiency. Most packaged software that is intended to maximize some efficiency measure for experimental design expects the researcher to specify just a *small* number of *discrete* levels for each attribute. As the number of attributes, and especially the number of values for these attributes, gets large, the number of possible unique combinations of attributes across all designs rapidly becomes huge. This dimensionality problem can slow the algorithm, so that (even fractional) factorial designs of a given size can be difficult to achieve.

This is also good place to note that there can be a tradeoff between design efficiency and the researcher's ability to specify models that assume smooth nonlinear marginal WTP (MWTP) functions that allow for diminishing (rather than constant) marginal WTP, permit interactions between attributes, or that permit interpolation or modest extrapolation of predicted MWTP amounts for transfer to contexts where the quantity of the attribute takes on a value not included among those few levels specified in the design. Researchers need to consider whether they are willing to give up some design efficiency to preserve an opportunity to fit MWTP as a nonlinear parametric function, either of the level of the attribute in question or the levels of other attributes. In general, researchers need to reflect upon whether it might be important to preserve an option to test for (a) the presence of diminishing marginal utility for any given attribute, or (b) the dependence of the marginal utility from one attribute on the level of another attribute. Packaged design algorithms sometimes default to maximizing the researcher's ability to estimate just the main effects in a choice experiment. This option can limit one's ability to estimate higher-order or interaction effects, and these may be important if one goal of the study is to transfer the estimated benefits function to a new context where the mix of attributes does not lie squarely within the range of attribute bundles used in the original choice experiment.

6 Modeling, Estimation, and Variable Selection

6.1 An overview of random utility maximization (RUM) modeling

Most researchers model people's preferences in a choice experiment using the random utility method (textbook treatments of RUM models are available and provide extensive detail, see Champ et al. (2017) and Mariel et al. (2021)). The default specification for the respondent's indirect utility function is typically linear and additively separable in the attributes of the different alternatives, so that indirect utility is modeled a linear combination of marginal utilities derived from each attribute times the level of that attribute. People are assumed to pick the alternative that will afford them the highest level of indirect utility.

It is the *difference* in indirect utility levels between any substantive alternative and the status quo (typically) that is assumed to drive choices. The absolute level of indirect utility is usually assumed to be affected by income, net of an alternative's cost. When indirect utility is additively separable in the net income attribute, however, the absolute level of each respondent's income (before paying for an alternative) drops out of the relevant utility-difference between each alternative and the status quo, leaving only the *change* in income (i.e., the negative of the alternative's cost). The negative of the estimated coefficient on a simple cost attribute still implies the respondent's marginal utility of income, which is used to divide their marginal utility from any other attribute, yielding an estimate of MWTP for that attribute (for example, in dollars per unit). The total WTP for any alternative can be calculated from a linear combination of each marginal WTP times the associated attribute level.[20]

6.2 Selection modeling

Many of the studies in our inventory offer descriptive statistics for their estimating sample as opposed to the population, typically for a small set of sociodemographic characteristics elicited from the respondent sample and likewise available for the general population. Many of these studies also comment upon whether the sample appears to over-represent or under-represent certain groups. Other studies report descriptive statistics only for the estimating sample. A few studies construct sampling weights to adjust the influence of over- or under-represented groups.[21]

In general, it is not possible to conclude that any given set of survey results is free from sample selection bias unless the researcher has some means to confirm statistically that the characteristics of the respondent (observable or unobservable) are essentially unrelated to their responses in the choice experiment (and thus unrelated to their WTP). If any individual characteristics that increase response propensity are also likely to affect their preferences as elicited by the choice experiment, any uncorrected preference estimates may not be representative of the intended population.

A key insight about sample selection modeling in choice experiments is that the researcher must plan for this analysis in advance, anticipating an obligation to demonstrate the representativeness of the estimating sample. Rigorous selectivity modeling can be undertaken only when sufficient analogous information is available for *both* respondents *and* nonrespondents to the main survey.

When a standing consumer panel is used, a research team might be able to negotiate with the survey firm to obtain whatever profile information is maintained for every panelist who receives an invitation to take the survey, rather than being limited to having this information only for the final respondent sample.[22] However, even if the firm does not maintain basic profile information for each of its panelists, an effort can be made, at the very beginning of the choice-experiment survey, to elicit basic geographic information (such as ZIP-code/ZCTA, in the U.S.) *before* an invited panelist learns the topic of the study.[23] Then jurisdictional characteristics at that

[20] Given that MWTP and total WTP calculations involve ratios of asymptotically joint normally distributed parameter estimates, and the expected value of a ratio of normally distributed random variables is undefined, one of a variety of approximation methods is generally employed when calculating point and interval estimates of MWTP and total WTP. An alternative, however, is to estimate the model in so-called "WTP-space," although some tradeoffs are typically involved.

[21] The only instance of some type of selection modeling in this inventory of papers appears to be Zambrano-Monserrate (2020). While Massfeller et al. (2022) employ a Heckman two-step model, they use it for a "hurdle" specification, rather than for sample-selection correction. Only a small minority of papers (e.g., Clucas et al. (2015), Bennett et al. (2018)) are careful to mention the risk of selection on unobservable characteristics of respondents.

[22] This has been done in a different valuation context by Cameron and DeShazo (2013).

[23] Institutional Review Boards (IRBs) may balk at a proposal to elicit every potential respondent's ZIP code prior to the survey page containing the Consent to Participate. A survey's Consent page typically outlines the subject matter of the survey, and some respondents may decide not to continue beyond that point. It may be helpful to emphasize to the IRB the obligation to ensure that the research they approve does not inadvertently (or purposely) exclude any groups in society. Without knowing at least something about the communities where people live (if not the individual themselves), it can be very hard to determine whether knowledge of the topic of the survey may have

level of geographic aggregation can also be employed in formal response/non-response modeling that explains whether an invited panelist completes the survey and thus appears in the final estimating sample.[24]

We note that conventional Heckman two-stage sample-selection correction algorithms based on the inverse Mills ratio (the hazard function for the response model) are technically not appropriate in a conditional logit model because the joint distribution of the errors in the selection equation and the "outcome" equation are uncorrelated due to the properties of the extreme value distribution that underlies standard choice models (Cameron and Kolstoe (2022)). This has not stopped some researchers from treating a fitted inverse Mills ratio from a selection model like any observable respondent characteristic and interacting it with a status-quo indicator to permit the inverse Mills ratio to shift WTP for any non-status-quo alternative (Yuan et al. (2015)). However, just using the fitted response propensity would be equally justified. Neither option produces a corrected second-stage model that accounts rigorously for selection bias in terms of a correlation in the joint distribution of the error terms in the selection model and the "outcome" model.

The usual Heckman-type two-step selection-correction method is appropriate *only* when the errors in the selection equation and in the outcome equation are *bivariate normal* (and potentially correlated). Thus, a choice experiment involving just one substantive alternative versus the status quo could have its utility function parameters estimated using a binary probit model, and packaged algorithms could be used to estimate a probit model with sample selection (as in Stata). But when the choice tasks involve more than just two alternatives, the joint estimation problem is more complex.[25]

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caused systematic attrition from the sample that make some groups more likely to be over-represented or under-represented in the analysis. For standing consumer panels, IRBs also may allow the elicitation of basic individual sociodemographic characteristics and zip codes prior to the "consent" page that informs respondents about the subject matter of the survey because these individuals have already given their permission to be used as respondents for a variety of research projects. Given that individual identifying information is never at risk for such panelists, and the fact that a zip code may be large enough to obscure their identities to any client of the survey research firm, a handful of sociodemographics and zip code information can help the researcher prepare for assessment of systematic selection into the survey that occurs at the point where the topic of the survey is announced to potential respondents. This information, unfortunately, cannot be known in the case of invitees who do not even begin the survey.

[24] There remains the question of whether people who volunteer to serve as members of a standing consumer panel have systematically different preferences for the environmental good being studied relative to the preferences of people who do not become panel members. High-quality (and thus more-expensive) panels are likely to be more diligent in recruiting panelists who span the entire spectrum of the population, and many panels will employ quota-based sampling to ensure that the final sample has descriptive statistics (typically marginal means or proportions) that match the marginal means or proportions for the corresponding characteristics in the population of interest. However, this does not necessarily mean that the people who show up in the final sample have exactly the same distribution of *unobservable* characteristics as occurs in the general population. All these concerns have the potential to bias the estimates of WTP derived for the estimating sample in terms of their suitability for extrapolation (scaling) to the general population of interest.

[25] A dissertation by Mitchell-Nelson (2022) includes a chapter on more-appropriate methods for correcting for sample selection in multi-alternative choice models. The relevant chapter is entitled "Ample correction for sample selection in the estimation of choice models using online survey panels." The correction method adapts code available in the R-based software package called Apollo.

6.3 Simple conditional logit choice models

The studies considered in the previous sections that employ true choice experiments often begin their analyses with a conventional conditional logit specification, where the respondent is assumed to have representative preferences and the specification of the indirect utility function involves fixed parameters. Only two of the studies mentioned above stop there, however. With improvements in techniques used to incorporate preference heterogeneity into choice model, almost every modern study now moves on to consider mixed (random-parameters) logit models and/or latent-class logit models.

6.4 Mixed logit and random-parameters logit choice models

Mixed logit models can be specified to allow the marginal utilities of each attribute to be random across the sample (but constant for any given respondent across multiple choice tasks for that individual). This specification can be called a random-parameters logit if *none* of the marginal utilities are treated as fixed parameters; the mixed logit typically includes some parameters that are random and others that are fixed (typically, at least the marginal utility of the cost attribute). The method of simulated moments is typically employed to estimate the means and standard deviations of the assumed distributions for each parameter, and most researchers now employ convenient packaged algorithms for estimation of these models. Parameters may be distributed according to a normal, log-normal, or triangular distributions (among others), depending on whether it is appropriate to restrict the sign on the parameter, or its range.

Instead of estimating just a single fixed marginal utility parameter for each attribute for a representative respondent, then, the mixed logit approach estimates both a mean and a standard deviation, across respondents, for each of the random parameters, where each estimate in these pairs (parameter mean and parameter standard deviation) has its own statistical standard error which permits hypothesis testing. The usual question is whether the estimated standard deviation for a given marginal utility parameter, across respondents, is statistically significantly different from zero. If this standard deviation is non-zero, there is deemed to be "heterogeneity in preferences" with respect to that attribute across the sample.

The simplest version of these models constrains to zero the off-diagonals of the *parameter* variance-covariance matrix (not to be confused with the usual variance-covariance matrix for the *estimates*, in a conventional conditional logit model estimated by maximum likelihood). Richer specifications can have fully unrestricted parameter variance-covariance matrices, permitting the individual marginal utility for one attribute to be correlated, across the sample, with the marginal utilities for other attributes. However, if there are k random marginal utility parameters, an independent mixed logit will have an additional k parameters for the standard deviations, and a correlated mixed logit will have $k + k(k-1)/2$ more parameters than a conventional conditional logit. Models with correlated parameters can therefore take much longer to coax towards convergence.

If the goal of a research project is to estimate average preferences in the represented population and to use those estimates to calculate an overall social benefits measure from mean WTP estimates, then mixed logit models can be perfectly adequate. However, two sets of circumstances can make mixed logit models less desirable. First, the researcher may be interested in the *distributional* consequences of some policy, so it will be important to identify which segments of the population are likely to enjoy larger or smaller benefits from the policy.

Simply the fact that preferences differ across the population is not sufficient information. The researcher will need to know *how* preferences vary across different groups, because it will be important to be able to distinguish which types of people have higher and lower WTP for the non-market good in question.

The second context where mixed logit models may not be appropriate is when the researcher desires to use the estimated model to predict WTP for a population that has *different* characteristics, and therefore possibly different average preferences, from the population represented by the estimating sample. Random-parameters or mixed logit models are designed to minimize heterogeneity bias when estimating the "mean" marginal utilities for choice-task attributes within the estimating sample. However, if the population to which the researcher wishes to transfer benefits estimates has different characteristics than the estimating sample, we would not expect the mean marginal utilities in the "policy population" to be the same as the mean marginal utilities estimated for the "study sample." Unless the researcher can be confident that the estimating sample is also representative of the "policy population," it is risky to rely upon mixed logit preference estimates to predict WTP in a benefits-function transfer exercise.

6.5 Latent class logit choice models

Latent class specifications assume that each respondent's preferences can be expressed as a finite mixture of a small number of latent preference "classes" (usually between two and four classes, in practice). Rather than assigning each respondent to a specific preference class based on their observable characteristics, each person has only a *probability* of being a member of each latent class. These models have two components, estimated simultaneously. The first component is a multinomial-type logit sub-model where the probability of belonging to each latent class (other than the baseline class) is modeled as a function of the respondent's observable attributes. If there are M latent classes, there will be M-1 different sets of parameters for these M-1 class membership equations (where the parameters for the baseline class are normalized to zero, for statistical identification). Then, conditional on membership in each class, M distinct sets of marginal utility preference parameters are estimated for these M classes. Latent class models can thus also be used to reveal that preferences are not homogeneous, but instead differ systematically with the mix of respondent attributes for each respondent.[26]

Latent class models are designed to estimate some small number of underlying "latent" preferences. Each respondent's individual preferences are then imagined to be some probability-weighted average of these underlying preferences, where the probabilities depend upon observable respondent characteristics. Given that latent-class models involve explicit heterogeneity in respondent characteristics, it is (in principle) possible to calculate different probabilities associated with each preference class for a new person who has any arbitrary set of these observable characteristics. However, it is very rare for researchers who estimate latent class models to calculate the distribution of WTP amounts in the population represented by the estimating sample (or by extension, for any other population with different characteristics). More typically, researchers focus on separate implied WTP amounts for each of the latent preference classes. To use a latent-class model as the basis for benefits transfer, researchers would need to work through the appropriate algebra to calculate probabilistic (expected) WTP estimates for a set of representative individuals, with specified characteristics, in the policy population.

[26] The researcher is left to decide upon an appropriate label for each latent class of preferences, based on the different respondent characteristics that tend to increase or decrease the probability of membership in that class.

6.6 Systematically varying marginal utility parameters

Rather than using mixed logit models, or latent-class models, it may be best to generalize a homogeneous-preferences conditional logit specification to allow each marginal utility in the model to be a function of respondent characteristics. For within-sample assessment of construct validity, it may be relevant to ask whether the different marginal utilities vary as one would expect with various respondent characteristics. For out-of-sample prediction about preferences, however, the dimensions of respondent heterogeneity used with the estimating sample must also be observable for people who were *not* in the estimating sample. Often, it is only possible to use variables that are known for people's neighborhoods or jurisdictions. More on this later.

6.7 Estimation to optimize out-of-sample predictive ability

This is a context where the most-appropriate systematically varying heterogeneous-preferences specification, for benefits-function transfer purposes, might be determined using LASSO (least absolute shrinkage and selection operator) criteria for variable selection. LASSO will retain those interaction terms between attributes and heterogeneity variables that minimize the mean squared error for predictions for different hold-out samples (where these hold-out samples are reserved from the full study sample). Conventional variable selection practices often tend to retain variables with the most statistically significant coefficient estimates, essentially maximizing "fit" within the full study sample. For benefits-function transfer, however, the goal is to identify a model that will perform well *outside* the study sample.

7 Considerations When Anticipating Benefits-Function Transfer

The usability of preference estimates based on a choice experiment, beyond the primary study, depends on whether the study is designed so that the estimated preference functions from the study can be employed (a) for policy alternatives where the policy's attributes differ from those described to respondents in the study sample and (b) for different populations of people (i.e., a "policy population").

Of course, there are many more issues to consider regarding benefits transfer than just those we highlight in this review. Johnston et al. (2021) offer a recent set of recommendations for the conduct of valid and reliable benefit transfers, and benefits-function transfers, in general.[27] The discussion to follow assumes that response/non-response modeling has been undertaken and corrections have been implemented if necessary. Also, if the estimating sample is known to under- or over-represent some identifiable groups in the population of the area from which the study sample is drawn, sampling weights can also be employed. It is important that the preferences estimated for the study sample, at a minimum, be scalable to the general population that the sample is intended to represent (i.e., avoidance of measurement errors, both in terms of unbiasedness, referred to as "validity," and in terms of precision, referred to as "reliability."). But it is also important that these estimates can be adapted for different populations (i.e., avoidance of "generalization errors").

[27] Our review of choice experiments relating to wild birds and their ecosystems, and the requirements for benefits-function transfer exercises in this context, is of course predicated on the history and evolution of research related to benefits-transfer more generally, likewise reviewed by Johnston et al. (2021).

7.1 When to start thinking about benefits-function transfer capabilities

To maximize the future value of any given choice experiment for benefits-function transfer, that longer-term goal requires forethought by the researcher well before the study commences. Future benefits-function transferability represents an additional value-added for a planned choice-experiment study after the completed research enters the literature. Choice experiments that are better-suited for future benefits-function transfers may need to feature more or different attributes, and estimation may then involve additional preference parameters. This more-complex specification will typically require more observations to achieve the same level of precision in the resulting benefits-function estimates. Fortunately, the marginal cost of additional observations needed for a model that is suitable for benefits-function transfer to a new context may be substantially less than the overall cost of an entirely new study for that new context. The researcher may need to outline (e.g., as early as during an initial research proposal) why it may be prudent to embed a choice-experiment design that can answer the immediate question within a more-general choice-experiment framework that will increase the future value of the estimated benefits function for use in other contexts.

7.2 Observable heterogeneity for both study sample and policy population

When the mix of characteristics in the policy population may not match the mix in the study sample, a model with systemically varying preferences is likely required. For benefits-function transfers, the dataset for the study sample used to estimate a preference function needs to include independently observable information related as closely as possible to each respondent. Respondent characteristics gathered directly from respondents themselves, during the survey, will rarely be equally available for everyone in the general policy population. Identical types of observable information need to be available for every person (or at least every person's community/jurisdiction) in the policy population. Personal identifiable information (PII) for individuals is generally protected, so the only data that are usually equally available for both the study sample and the policy population are likely to be community or jurisdiction-level characteristics. Smaller, less-aggregated types of jurisdictions are preferable, since aggregated statistics for large jurisdictions will obscure a lot of individual-level or local-level heterogeneity in the population.

7.3 Controlling the dimensionality of observable heterogeneity

For benefits-function transfer applications, preference parameters in the choice model may be allowed to vary systematically with observable sociodemographic and income characteristics, but usually only for respondents' neighborhoods (e.g., ZIP codes, census tracts, counties, or similar). Preferences can also be allowed to vary systematically with characteristics of the local geography (such as land use, land cover, or type of land management), which may help control for opportunities for public access and the availability of substitutes or complements.

Spatially disaggregated census-type data are typically calculated as proportions of the population in different categories. Many different census variables also tend to be rather highly correlated over space. As a result, models using the study sample can be afflicted by multicollinearity that makes it difficult to discern the independent contribution of any one jurisdictional characteristic. Capturing all the census-data heterogeneity that could be important to preferences can also require a huge number of interaction terms between the census variables and the attributes of each alternative in the model. In the presence of multicollinearity, outliers can be influential, so that the apparent systematic variation in preferences, especially in smaller study samples, may be misleading.

In the presence of large numbers of correlated measures of observable jurisdictional heterogeneity, one recourse is to use factor analysis to first extract a much smaller number of orthogonal factors (using the universe of census data) that span essentially the same space. The factor scores from this factor analysis could be estimated, for example, using a nationwide sample of county or ZIP/ZCTA data. The relevant geographic subset of observations for the resulting factor scores, for the study sample, could then be used in estimation of the systematic variation in preferences. Then the estimated preference parameters can be combined with the nationwide sample of factor scores to predict benefits estimates for other regions of the country.

7.4 External disaggregated spatial data on relevant special interests

In some circumstances, in addition to any land use, land cover, or land-management data that may control for public access and the local or regional availability of substitutes/complements, the researcher may be able to identify specific highly detailed nationwide spatially indexed datasets that measure people's attitudes or behaviors that (a) are particularly relevant to the valuation of wild birds, and (b) are also available with great enough geographic resolution over a sufficiently wide geographic area. This is akin to what Holmes (2020) posits as a value to novel data sets (though he used social media (e.g. Flickr) in his example) for estimating the value of environmental quality on a larger spatial and temporal scale.[28]

Suppose one of these auxiliary datasets measures just one or two characteristics or attitudes/opinions, among a large enough sample of individuals from the general population, which are likely to be relevant to preferences concerning wild birds and their habitats. If the auxiliary dataset measures numerous characteristics or opinions, factor analysis could likewise be used to reduce these data to just one or two factors that span the same space. This information needs to be available, for example, on a ZCTA-by-ZCTA or county-by-county basis. If enough ZCTAs/counties with adequate variation in these characteristics/factors are represented in the study sample, then these characteristics/factors can be used to reflect relevant systematic variation in preferences at the ZCTA or county level more widely. The estimated benefits function could then be employed with the different levels of these characteristics/factors in the rest of the area covered by the nationwide ZCTA/county-level dataset in question to predict expected benefits from wild birds and their habitats in those non-surveyed regions.[29]

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[28] Johnston et al. (2021) also note the value of auxiliary data. However, they emphasize its value in meta-function development to combine a suite of original studies, and for preference calibration exercises (see p. 582).

[29] Stanford and Cameron (2024) report on a choice experiment about cap-and-trade programs conducted in just one U.S. state. They allow the preference parameters to vary systematically with factor scores derived from a nationwide survey of climate change attitudes known as the Yale Climate Opinion Map data (see https://climatecommunication.yale.edu/visualizations-data/ycom-us/). The Yale data have been collected over roughly two decades for repeated cross-section samples of the U.S. population. The providers use a modeling process, outlined in Howe et al. (2015), to fill in predicted response proportions for counties that have missing data. These predicted climate attitudes are available at the county level for the entire U.S. The raw data consist of a set of roughly sixty predicted population proportions related to thirty different attitudinal questions. However, these proportions can be reduced by factor analysis to yield one primary factor that captures more than 80 percent of the

Researchers contemplating choice experiments concerning wild birds and their habitats need to identify sources of data related to human involvement with birdwatching or related activities, or local land-use, land-cover, or land-management characteristics that are more-closely or less-closely related to wild birds. WTP measures are based upon human preferences concerning wild birds. Ideally these auxiliary datasets are available at a high level of geographic resolution. A citizen or community-science project with national or global penetration is one possibility for such data.[30]

Hypothetically, for example, it might be possible to characterize eBird membership and/or engagement levels, per capita, at the county level for the entire U.S. (or for administrative jurisdictions in other countries, since the platform is used worldwide). If eBird membership counts, as a fraction of county population, are missing (or too sparse) for some counties, it might be possible to model eBird membership or engagement levels as a function of various county-level census sociodemographic and economic variables, as well as geographic information about proximity to wildlife refuges or major flyways for migrating birds or other ecosystems that would attract birders. Such a model could then predict eBird membership or engagement levels in every county, and these complete sets of predictions could be used in lieu of the actual data with its assorted missing county observations.[31] This complete dataset could then be used to identify systematic variation in preferences from a choice experiment conducted in just one state (or a subset of states exhibiting adequate variation in predicted county-level eBird involvement). The estimated benefits function could then be transferred to other states, to other regions, or perhaps even to the entire U.S.[32]

For the U.S., administrative surveys such as the quinquennial National Survey of Fishing, Hunting and Wildlife-Associated Recreation (FHWAR) might also come to mind. Depending on the year, the survey's data are either available at the state level or only at the region/division level. The 2016 50-state survey and 2022 survey were carried out differently than the surveys of prior years, thus the official reports point out "the estimates are not directly comparable to those from previous surveys."[33] In particular, in 2022, the survey used both probability and non-probability samples due to declines in response rates for prior surveys. Reliance on only state-level (or region-level) jurisdictional data for benefits-function transfers has important implications for the necessary geographic scope of the original choice experiment. Any choice experiment fielded only in one state (or region) would then only have one set of values for its associated FHWAR data. In that case, there would be no variation across the estimating sample in observed participation in wildlife-watching from the FHWAR (by which preferences could be

variation in climate attitudes across the 3,107 counties in the continental U.S. This factor also exhibits sufficient variation across the 36 counties represented by the individual respondents in the study sample, permitting identification of systematic variation, by these climate change attitudes, in the preferences estimated from the choice experiment.

[30] The question of the availability of auxiliary contextual data for benefits-transfer exercises generally relates to situations where a meta-analysis of alternative studies is being used to predict benefits for a policy site. These auxiliary data sources are typically used to explain differences in estimates across different studies for use in meta-transfers, not to explain heterogeneity in benefits within a single study sample where the benefits function is being designed to maximize transferability (see Johnston et al. (2021), p. 602).

[31] Such a model can mimic the strategy used in generating Yale Climate Opinion Map data for all U.S. counties.

[32] Benefits-function transfer exercises are riskier between different countries. However, it may be possible for some other countries to make the case that eBird engagement levels are correlated, in essentially the same way, with preferences for wild birds and their habitats.

[33] See https://www.fws.gov/program/national-survey-fishing-hunting-and-wildlife-associated-recreation-fhwar/50-state-survey

allowed to vary systematically). In any event, averaging people's behaviors over larger and larger geographies obscures more and more individual/local variation that might help explain differences in preferences. While the FHWAR might have been a somewhat more promising source of information about heterogeneity in wildlife-watching behavior for benefit-function transfer exercises when it was still available at the state level, it has been rendered mostly inappropriate for this purpose by limiting the publicly available data to regional geographic divisions only.

8 Considerations for Future Studies

The Supplementary Materials associated with this review include an extensive spreadsheet that documents a long list of features for most of the studies in our inventory. Appendix A summarizes the list of column headings for the different study features in our spreadsheet. As of this point, about 58 different choice experiments are currently included in that spreadsheet, along with about 22 contingent-valuation or other studies relating to the valuation of wild birds and their habitats. In our spreadsheet, the different features for the set of choice experiments have been more-completely documented than those for the contingent valuation studies. Our intent in this chapter (and in our commentary in the associated spreadsheet) is to assess the suitability of these studies for use in benefits transfer. Even though a particular study may make important contributions in other ways and may have more than fulfilled its initial specific objectives, those achievements have not been our focus in this chapter. We stress that most of the studies we have mentioned in this chapter were never explicitly designed to be useful for benefits-function transfer. Nor were their models employed, even in the original paper, for any type of benefits transfer (although Yao et al. (2019) is a notable exception).[34]

Johnston et al. (2021) affirm that "original valuation studies are not typically conducted or documented in a manner that supports benefits transfers," whereupon they go on to describe some of the institutional incentives that account for this problem. In this chapter, we have addressed only a few of the features of our inventory of choice-experiment and contingent-valuation studies relating to wild birds and their ecosystems, focusing on those features which are particularly important concerns in studies intended for use in subsequent benefits-function transfer exercises. We also acknowledge, again, that excellent and interesting new studies continue to be published at an impressive rate, and we may not have captured every single relevant paper with our snapshot of the literature.

We conclude this chapter by consolidating some of the key points in our discussion above into a set of "considerations," relating to transferability, that researchers may wish to take into account as they design a new choice experiment or other stated preference study related to wild birds or their habitats (or, indeed, for similar studies in other contexts). Many government agencies rely almost exclusively on benefit-transfer to conduct their regulatory analyses. Thus, while benefit-function transfer applications may often lie beyond the original scope of work for a

[34] Yao et al. (2019) push their analysis all the way through a benefit-cost analysis at the national level. However, rather than using sociodemographic characteristics as sources of heterogeneity in their choice model, they use a mixed logit specification and calculate predicted individual marginal WTP estimates for each respondent. Then they separately regress these individual WTP amounts on characteristics of the respondent and their Census unit. Predicted WTP can then be calculated for a representative individual from each Census unit, permitting their nationwide benefit-cost analysis.

study, the social value of any such research effort can be multiplied if the benefits functions produced by the study can later be transferred to other contexts.

Consideration #1: Include an explicit cost attribute

Whenever a choice experiment describes alternative programs or policies that affect wild birds and/or their habitats, it is very important to include a cost attribute. Some studies have not done so. For example, Garnett et al. (2018), do not include program cost as an attribute, using the rationale that "the costs would be met from government tax revenue…rather than from direct personal donations." But most people appreciate that taxpayers ultimately bear the cost of government expenditures, and many people have strong preferences over how "their" tax dollars are spent. Tax revenues are collected from households and have other uses. The omission of a cost attribute leaves respondents to impute whatever they wish about the real but unspecified opportunity costs of each program, and whether these costs are likely to differ across alternative programs.

With no monetized attribute, it is not possible to calculate the implied WTP for any of the programs or the MWTP to protect any of the species being considered. Failure to mention cost, especially when respondents may automatically impute costs that vary directly with program "size," can risk creating omitted variables bias in the apparent marginal utility of other attributes that are likely, in the real world, to be correlated with costs that are ultimately born by individual households as taxpayers.

Consideration #2: Use explicit measures of biodiversity

Wherever possible, it is preferable to elicit respondents' trade-offs with respect to quantitative (rather than just qualitative) measures of wild bird biodiversity or abundance, and then it may be possible to map these attributes onto accepted scientific measures of these concepts. Species richness (a count of the number of different species present) seems to be the most popular and/or expedient measure of biodiversity. Boeri et al. (2020), however, make a valiant effort to try to determine just which measures of biodiversity are given more or less attention by respondents as they choose between different programs.[35]

Consideration #3: Quantify the effect of a bird-related program on the birds themselves

Whenever possible, there is value to having choice scenarios that quantify the effects of each alternative in a choice experiment on well-defined bird populations. It is important not to be vague. For example, Gatti et al. (2022) study demand for bird-friendly environmental certifications for coffee. The bird-friendly certification is a binary variable, and this research seems to have missed an opportunity to ask respondents to consider different certification programs that would lead to different expected improvements in avian biodiversity due to the

[35] Unfortunately, these biodiversity measures are described to respondents in their study only in terms of increases or decreases relative to the status quo, with no quantitative information about the sizes of these changes (which may be anything from miniscule to huge in the minds of respondents). From this choice experiment, therefore, it is only possible to determine whether people care about *directional* changes in any of these measures. Without specifying the sizes of the changes, marginal WTP for one-unit changes in any of the biodiversity measures cannot be derived from people's choices.

certification program.[36] People's demands for a program or policy intended to help wild birds are presumably derived from their demands for protection of these species. The researcher's ability to learn about these underlying demands will be hampered if the connection between the program/policy and wild birds is not specified, or if no information at all is provided to respondents about the expected *extent* to which any particular species or category of bird may benefit from a given program/policy. To be able to estimate marginal WTP per species or per bird, it is necessary to specify "by how much" species richness or abundances would be expected to change under the different alternatives. For example, some studies in our inventory consider improved farming practices intended to help wild birds, but their choice experiments seek only to value the overall willingness to accept compensation for adopting these practices. This willingness is derived from farmer's concerns about wild birds, but these studies do not directly value the birds themselves (e.g., Valasiuk et al. (2018), Czajkowski et al. (2021)).

Consideration #4: Measure wild-bird attributes on continuous cardinal scales

Mere qualitative or directional changes, without natural units, are not generally appropriate if the goal is to estimate marginal WTP for specific changes in wild bird populations or their habitats. Wherever possible, attributes related to wild birds or their habitats are easiest to use in benefit-function transfers when they are measured on a continuous and cardinal scale, even if only a few different examples of levels are employed. It is valuable to know the marginal WTP for an additional species or an additional individual bird (either in general, or specifically for endangered species). It may also be valuable to know whether people experience *diminishing* marginal utility for additional species or bird. Attributes specified only in terms of intervals can preclude marginal WTP estimates (e.g., Steven et al. (2017)). Johnston et al. (2021) similarly note the trouble with ambiguously defined measurements such as "high, medium, low" (p. 602). Likewise, the conversion of quantitative information provided in the choice tasks into interval form prior to analysis (e.g., Yao et al. (2014)) forfeits the option to estimate marginal WTP or to ascertain whether marginal WTP is increasing or decreasing. There are similar drawbacks to using presence/absence indicators as a program attribute (e.g., Sehra and MacMillan (2021)).

Consideration #5: Avoid conflating effects on wild birds with other policy effects

Bennett et al. (2018) use a choice experiment designed to estimate farmers' willingness to accept compensation for changing their pesticide usage, describing birds as a reason why farmers might want to do this. They elicit subjective information about how likely it is that pesticides are to be harmful to large birds and small birds, but this information is not sufficient to infer farmers' assumptions about just *how many* birds of each type might be protected by the programs

[36] If it is deemed too complex/confusing to include changes in bird biodiversity as an explicit attribute of each certification program in the actual choice sets presented to respondents, where biodiversity effects differ across choice tasks, perhaps biodiversity effects can be made explicit in the common preamble to the choice tasks. Rather than being identical for all respondents, however, this contextual information might be allowed to differ across respondents as part of the experimental design, and these different overarching choice-scenario conditions can be modeled as additional attributes. For benefits-function transfer applications, it would be valuable to be able to translate the WTP for a certification program, for example, into a WTP for greater biodiversity in bird populations more generally.

described in the choice experiment. However, the preamble to these choices also talks about "ground- and surface-water pollution [that] can adversely impact rural household health…can damage and unbalance the regional ecology by harming important bird and animal species, by killing off natural predators of pests…." Thus, the respondents appear to have been encouraged to think beyond just birds as benefiting from pesticide reductions. In other contexts, it is easy to imagine that respondents might also easily impute program benefits for a variety of species other than birds, even though benefits for these other species are not included as a separate attribute in the choice tasks. This could again lead to omitted variables bias in the marginal utilities estimated for just the birds. There are just a few valiant efforts, in the literature, to convert overall program values into implied per-bird values (using essentially back-of-the-envelope calculations). However, the resulting average per-bird values may be overstated by these calculations if total value includes other (implicit) types of benefits as well. (See Collas et al. (2023) and Collas and Balmford (2023)).

Consideration #6: Avoid valuing just one or two *specific* local bird species

Sometimes the research budget is small, and thus it is not possible to embed the species of particular interest in a study that is more general and therefore more useful for future benefits-function transfer. Each additional attribute (for which a marginal utility must be estimated) adds to the sample size necessary to identify all the marginal utilities in the model. But where budgets permit, it is desirable to ensure that the species of greatest current interest in the original study can be classed as a special case of a wider range of species with different levels of the same set of attributes. Perhaps some studies, as originally conceived, can be expanded prior to the fielding of the survey. Is it possible to include, for choice tasks posed to the study sample, other species that collectively span the ranges of a key set of attributes that will be relevant more widely? If different mixes of the attributes used to describe the species of current interest can then also be used to describe a wide variety of other wild bird species in other regions, the study will have greater promise for subsequent benefits-function transfer exercises.

Consideration #7: Avoid using respondents' own attitudes/opinions to explain their WTP

Ideally, systematic variation in preferences is a function of observable respondent characteristics that are exogenous (or at least predetermined relative to the choice tasks they are being asked to consider). It is risky to model preferences as depending on the respondent's own subjective attitudes about wild birds or their habitats, because these attitudes have the potential to be jointly endogenous with the individual's preferences for the wild-bird-related program or policy being addressed in the choice experiments. Where available, it can be more appropriate to use some exogenous aggregate community-level measure of the typical attitudes or opinions in the respondent's neighborhood (e.g., ZIP code/ZCTA, or county).[37]

[37] If people sort into neighborhoods based on their attitudes and opinions, however, there may be some unavoidable degree of endogeneity between the respondent's preferences as elicited in the wild-bird-related choice tasks and these attitudes. In the spreadsheet included with the Supplementary Materials, we document whether specific papers incorporate exogenous/predetermined heterogeneity, behavioral heterogeneity, or attitudinal/belief heterogeneity.

Consideration #8: Use an incentive-compatible choice format and an efficient design

A binary choice (referendum) between a specific program and the status quo is generally considered to be the most incentive-compatible format. However, tradeoffs are sometimes necessary, especially when there is insufficient funding for a larger sample. Efficient design methods can increase the information that can be collected from any given number of respondents. Sometimes, multiple-choice formats can be combined with binary choices, along with an indicator in the model for the type of choice format, where the estimated coefficient(s) on interactions with this indicator can be used to correct for any distortions introduced by a less incentive-incompatible multiple-choice framework. However, some types of choice-set designs can limit the researcher's ability to estimate of nonlinear specifications or interaction effects.

Consideration #9: Avoid convenience samples due to risk of avidity-based selection bias

Convenience samples are certainly cheaper, and they may indeed be adequate for pretesting a choice experiment and obtaining approximate parameter estimates for use in generating an efficient design for choice tasks in the main survey. But consider how much is lost by failing to get an estimating sample that is representative of the population of interest (and allows estimation of a preference function that is also potentially transferable to other populations). If people self-select to take the survey based on their interest in the topic, biased inferences are a threat. If a survey is delivered on-site to people who are already participating in an activity related to wild birds, for example, their preferences will, at best, match the preferences of people who go birding at that location. However, since more-avid birders are more likely than average to be present at any giving birding location, even the sample that is obtained via site intercepts will over-represent avid birders relative to less-avid birders. Any attempt to correct for self-selection on unobservable characteristics such as "birding avidity" will require, at a minimum, that the researcher know something about both the people who participate in the choice experiments and people who choose not to complete the survey. Ideally, if the researcher knows at least some locational information about both kinds of people, then they can include variables from auxiliary data sources that might proxy, at least in part, for birding avidity, concern about wild bird habitat, access to opportunities and substitutes, and so on.

Consideration #10: Plan for national-scale benefit-function transfer from the outset

Even though the funding for a project might dictate a scope-of-work that focuses on just one species in just one area, the social value of the research can be greatly enhanced if the estimated benefits function is transferable and can be used to value other species in other jurisdictions or regions. If at all possible, early the planning/conceptualization stages for a choice experiment study, it is prudent to envision how the opportunity to collect data during one particular study may possibly be leveraged so that the estimated benefits-function model can be transferred to other contexts in the future.

9 Conclusion

Stated preference methods are widely used in the nonmarket valuation literature to value nonmarket goods, including ecosystem services associated with wild birds, as illustrated by the approximately 80 published studies we have reviewed in this chapter. Best practices for stated preference research will continue to evolve, and practitioners will need to continue to adapt study design and their analyses to incorporate these improvements. This chapter has focused mostly on choice experiments as the more-general of the two main stated-preference approaches (as opposed to contingent valuation studies), because the flexible design of choice experiments can make them more suitable for modeling willingness to pay as a function of an array of attributes, facilitating the transfer of the estimated benefits function from the study sample to different contexts with different combinations of policy attributes and different populations of people.

The design of any choice experiment must reflect the primary objective of the study, such as the value of bird-related ecosystem services. However, additional considerations at different stages during the research—from conceptualization, through the design of the survey, the analysis, and/or the reporting of the results—can render such a study more useful for potential future benefits-transfer exercises. Policy decisions may require nonmarket benefits estimates for some specific type of environmental good or ecosystem service for a particular geographic location or region. However, if there is no exact match in the literature for the relevant context, then agencies must employ some sort of benefits transfer (or benefits-function transfer) from the closest available study, or triangulate, via meta-analysis, among a number of imperfectly matched studies. For benefit-cost analysis of a proposed or final regulation, the timetable and available budget may be limited and binding (Holmes (2020); Newbold et al. (2018)). Thus, original research can maximize its future value beyond the immediate scope of work by accounting for the considerations (#1 to #10) outlined above in Section 8, which can enhance the study's future value and ease of use for benefits-function transfer.

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