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A CONSERVATION MARKETING TOOLKIT: SYSTEMATIC LITERATURE MAPPING, MICROTARGETING CONSERVATION EASEMENTS, AND CONSERVATION CORRIDOR PRIORITIZATION

By

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B.S., Business Administration, University of Montana, Missoula, Montana, 2015

Thesis

presented in partial fulfillment of the requirements
for the degree of

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in Resource Conservation

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A Conservation Marketing Toolkit: Systematic Literature Mapping, Microtargeting Conservation Easements, and Conservation Corridor Prioritization

Chairperson: Dr. Alexander L. Metcalf

In a changing world with limited resources for conservation efforts, conservationists, wildlife managers, and land managers must look for creative ways to realize conservation goals. A new wave of conservationists is investigating how other disciplines, namely psychology and marketing, might improve our ability to understand and change conservation-related human behavior. In this thesis, I review existing applications of "conservation marketing" and apply a subset to advance two specific conservation challenges. In Chapter 1, I present a systematic mapping of the conservation marketing literature to understand the lay of the land in how conservationists have already applied marketing techniques to conservation, and where the gaps and opportunities seem ripe for future research. In Chapter 2, I employ one specific marketing technique, microtargeting, to help advance efforts to secure conservation easements on private land. Using a suite of modeling and analysis techniques to estimate landowners' willingness to participate in a conservation easement, I was able to nearly double easement predictive power over random. In Chapter 3, I apply these willingness scores to advance a contemporary conservation issue: conservation corridor prioritization. Specifically, I use the easement propensity scores derived from Chapter 2's model results to evaluate three proposed conservation corridors for grizzly bear *(Ursus arctos horribilis)* migration between two isolated habitats in Western Montana. With this study, I hope to enhance the ways conservationists understand and use marketing techniques to achieve conservation goals more efficiently and effectively.

ACKNOWLEDGEMENTS

Thank you to everyone who helped me along this wild ride! A big thanks to my advisor, Dr. Alexander Metcalf for his constant reassurance and ample track changes throughout my time as a master's student. Thank you to my committee members, Dr. Justin Angle and Dr. Martin Nie, for their expertise as well as for their patience with my timeline. A special thank you to Dr. John Chandler for his guidance through data analytics and statistics and for taking so much time to walk me through each step and coding error. I could not have made it through my master's without my good friend Dr. William Janousek who started his journey of helping me by holding my hand through my first teaching assistant position in wildlife biology (after I took this job from him) and through numerous questions and food briberies. I'm thankful for my lab mates in the Human Dimensions Lab for helping me weed through copious amounts of data and always being willing to guide productive discussions. Finally, a huge thank you to my friends and family who kept me on track and sane throughout this journey.

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Chapter 1

A Systematic Mapping of Conservation Marketing Literature: Current applications and opportunities for the future

INTRODUCTION

Marketing is often credited with profound influence over society's purchasing decisions and consumer behaviors, and frequently villainized for exacerbating environmental degradation (McKenzie-Mohr, D. 1994; Foxall, Castro, James, Yani-de-Soriano, & Sigurdsson, 2006; Veríssimo & Mckinley 2016; Hobson 2017). Despite its notorious reputation, a growing subset of conservation practitioners and researchers are asking how the power of marketing can be reimagined and repurposed to solve conservation challenges, rather than perpetuate them. However, it is unclear whether conservation marketing and marketers are matching their efforts and focus to the magnitude of these global, environmental problems. In this chapter, I explore the evolution and current state of the literature on this emerging field of "conservation marketing."

The American Marketing Association (AMA) defines marketing as "the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large." Contemporary marketing's success is tied to techniques designed to influence a target audience to voluntarily accept, modify, or abandon a behavior (Sheau-Ting et al., 2013). Marketing has often been used to encourage consumer choices, which are frequently blamed for detrimental consumerism and many corresponding environmental problems like pollution, waste disposal, deforestation, overfishing, water consumption and many more (Van Raaij, 1988; Foxall et al., 2006; Veríssimo & McKinley, 2017). Perhaps counterintuitively, there is growing curiosity among conservationists to explore whether and how marketing theories, tools, and techniques might be used to amplify conservation efforts to achieve desired environmental outcomes (Smith et al. 2010; Wright et al.

2015; Veríssimo & McKinley 2016, 2017; Metcalf et al. 2019(a), Metcalf et al. 2019(b)). Several studies have been conducted on the effectiveness of changing consumer behaviors using marketing techniques for the betterment of conservation (Veríssimo 2019). For example, recent titles have included, "Applying marketing to conservation: A case study on encouraging boater reporting of watercraft collisions with Florida manatees" (Flamm & Braunsberger 2014), "Segmenting and Profiling South African Households' Electricity Conservation Behavior" (Issock Issock, Mpinganjira, & Duh 2017), and "Social marketing's role in improving water quality on the Great Barrier Reef" (Hay, Eagle, & Saleem 2019). Not all efforts are successful, and more research is needed to better understand how marketing can best advance conservation outcomes and in what contexts it is most applicable (Veríssimo, Bianchessi, Arrivillaga, Cadiz, Mancao, Green 2018).

Past research has demonstrated that marketing techniques can be used to positively incite behavior change and that there is opportunity for boundless research within the field of conservation marketing —from better understanding target audiences' values, to influencing individuals' behavior in their consumption of natural resources (Wright et al., 2015). To realize these opportunities, however, more interdisciplinary approaches are needed to merge insights from fields such as social psychology with the design of conservation-oriented marketing campaigns or program plans (McKenzie Mohr, 1994; McKenzie-Mohr, 2012). Many current conservation marketing campaigns fall short of success or effectiveness because they fail to engage this crucial behavioral tool that many commercial marketers have mastered to sell goods and services (McKenzie-Mohr 1994, 2000).

Despite the promise offered by conservation marketing applications, some academics have expressed foundational doubts that using the techniques which inspired overconsumption can solve its resulting problems, noting the failure of social marketing to adequately alter behavior towards more environmentally sustainable ends (Hobson 2017). Even authors promoting social marketing for conservation have questioned its potential efficacy, due mostly to misunderstandings of social psychological principles driving behavior change (McKenzie-Mohr 2000; Smith et al. 2010). For

example, many conservation or social marketing campaigns focus on elevating awareness or knowledge around a particular issue but fall flat when it comes to promoting actual behavior change necessary to achieve conservation success (McKenzie-Mohr 1994, 2000; Veríssimo et al. 2018).

Despite, or perhaps because of this skepticism of the field's potential efficacy, there has been a growing interest around "conservation marketing" within the academic community. This relatively new concept in the resource conservation arena is increasingly regarded as an integral part of the conservation toolkit. For example, in 2014, the Society for Conservation Biology created the Conservation Marketing and Engagement Working Group (ConsMark) whose mission is to support investigations and applications of marketing to meet conservation challenges. Members of ConsMark have adopted a definition for conservation marketing which establishes the approach as, "the ethical application of marketing strategies, concepts, and techniques to influence attitudes, perceptions, and behaviors of individuals, and ultimately societies, with the objective of advancing conservation goals" (Wright et al., 2015, p. 46).

The feature which differentiates "conservation marketing" from commercial applications is simply the objective sought by the marketer or practitioner. All marketing campaigns begin with establishing the objective of their efforts which then serves as a road map for the rest of the campaign development as well as a baseline for evaluating campaign efficacy or success (Figure 1).

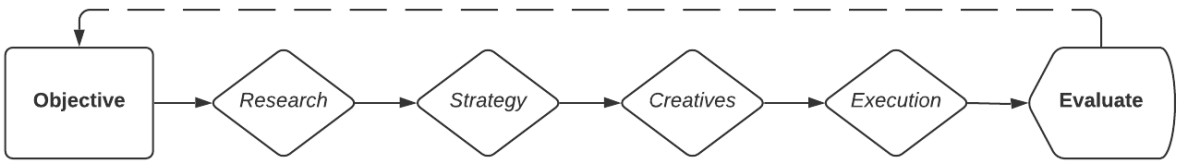

Figure 1 Marketing Process Flow

After establishing the objective, market research is necessary to determine the viability of a new product or service on the market (Marketing Accountability Standards Board (MASB), 2020). This can be completed with qualitative and quantitative data and primary and secondary data. Some examples include

surveys, focus groups, and interviews. Next, marketers create a strategy, often using segmentation, targeting, and position (STP), as well as message development and delivery tactics. The first steps of strategy development (STP) are often referred to as “market segmentation” and involve identifying groups of people within a market and profiling each group’s characteristics and tendencies (Bowen, 1998). Messaging within marketing strategy refers to how an organization talks about itself and the value it provides to its customers. An organization's message has the power to influence the target audience and enhance the efficacy of marketing. Delivery tactics are the strategic actions that direct the promotion of a product or service to influence specific marketing goals (CoSchedule, 2020). There are numerous examples of delivery tactics from paid advertising, endorsements and influencers, social media, email, and gamification, just to name a few.

Creatives, often recognized generically as advertising, are the visual and/or auditory information prepared by a marketer to inform and/or persuade an audience regarding a product, organization, or idea (MASB, 2020). Advertising is often conflated with the entirety of marketing; in truth, advertising is but one piece of the broader, more holistic marketing process.

Execution is the launch and delivery of a marketing campaign. This is the culmination of the process which began with a stated objective and evolved through marketing research, strategy creation, and creative development. Finally, once the marketing campaign is complete, it is generally helpful to evaluate its success or failure. During evaluation, the campaign performance is analyzed and compared to the goals articulated by the objective. Thus, marketing campaigns are an iterative process where campaign evaluations help to improve subsequent rounds of market research, strategy development, creative production, and re-execution.

Social good marketing follows the same process flow as commercial marketing outlined in Figure 1, with the sole difference being the objective outcome. Desired outcomes for commercial applications of marketing consist of industries like automotive, food, textiles, or technology that provide a good or a

service (Figure 2). In contrast, social good marketing focuses on changing people's behavior for the benefit of individuals or society as a whole. In social good marketing, the "product" can be a behavior or lifestyle that benefits society. To better understand social good marketing, I broke it into four areas of application: health and safety, social activism, policy, or conservation and environmental, the latter of which constitutes the field of "conservation marketing" (Figure 2).

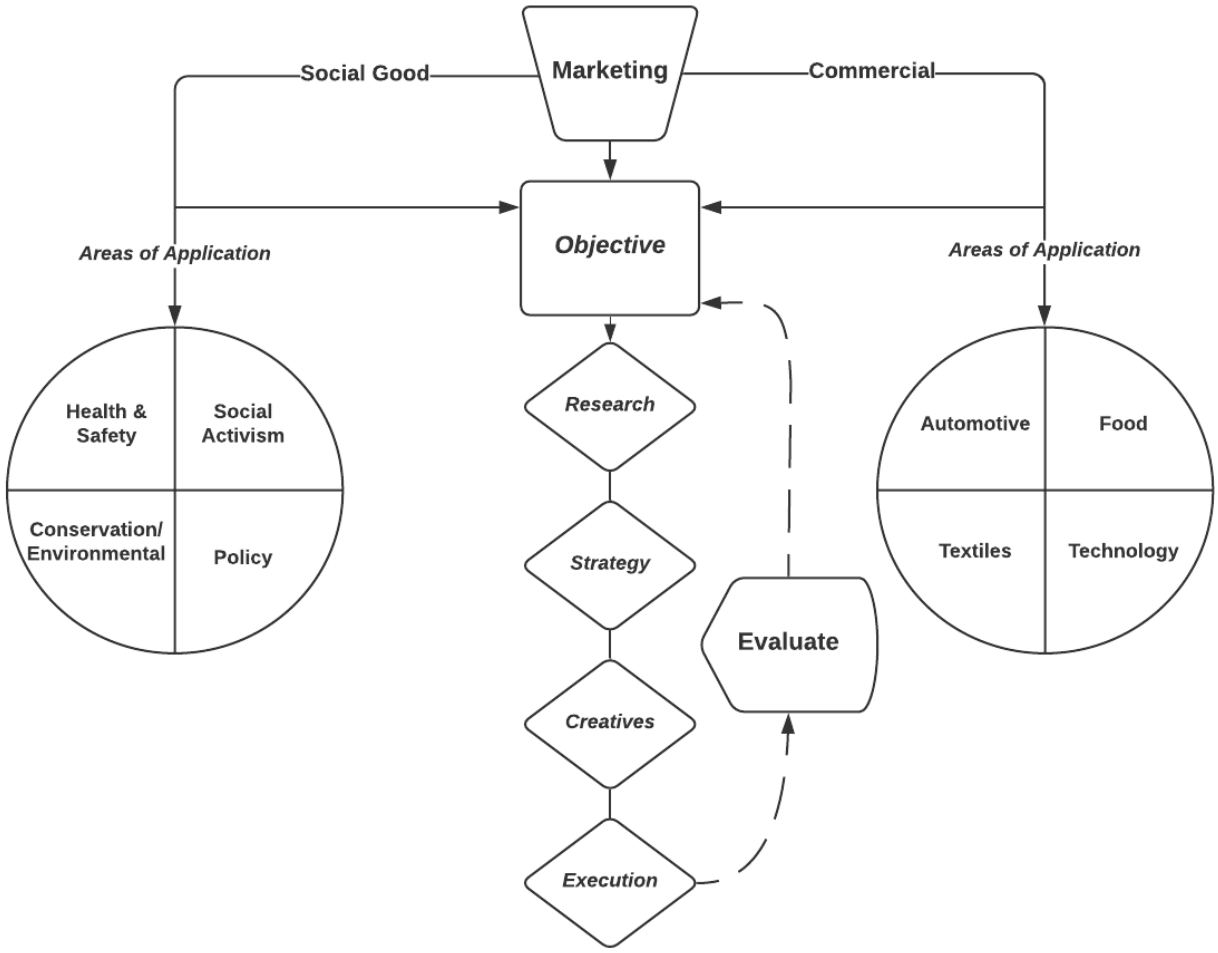

Figure 2 Marketing Process Flow Social Good vs. Commercial Marketing

Despite growing interest in the field, the nature of conservation marketing research and the issues to which it is applied are surprisingly not well synthesized. Further, the environmental challenges facing society are monumental and existential; it's unclear whether the application of marketing is matching the

scale of the problem with corresponding solutions, or if conservation marketing is simply scratching the surface around issues such as consumerism and conservation of individual, wildlife species. Examples of unanswered questions include: do certain aspects of the marketing process receive greater or lesser attention among conservation marketing researchers?; Is conservation marketing more or less applied to different environmental challenges, and are there missed opportunities to apply these techniques to advance needed conservation solutions?; On what types of outcomes, and among whom, do conservation marketing researchers tend to focus?; Is conservation marketing only applied or applicable to individual behavior change efforts, or are there broader applications happening or possible? Answering questions like these will advance conservation marketing by delineating where research investments have already been made, articulating those questions yet unexplored, and identifying important opportunities for knowledge creation as the field evolves.

To achieve these goals, I conducted a systematic mapping exercise of the conservation marketing scientific literature. I chose a systematic mapping approach because it afforded a transparent, objective, and comprehensive method for summarizing the character and extent of marketing techniques used in various conservation spaces. This exercise proved useful for outlining and highlighting conservation marketing's landscape of what has been done and where the missed opportunities lie providing a roadmap for future research.

METHODS

To conduct a relatively fast, yet comprehensive review of the literature, I used a hybrid method blending the strengths of a systematic review with those of systematic mapping. A systematic review is, "a form of secondary study that uses a well-defined methodology to identify, analyze, and interpret all available evidence related to a specific research question in a way that is unbiased, and (to a degree) repeatable" (Kitchenham, 2007, p.vii). In contrast, systematic mapping is, "a broad review of primary studies in a specific topic area that aims to identify what evidence is available on the topic" (Kitchenham, 2007,

p.vii). By blending these approaches, I sought to broadly identify primary conservation marketing studies and analyze the nature of their inquiry while stopping short of secondary or meta-analysis.

I followed established procedures for systematic reviews of conservation literature from Pullin & Stewart (2006) and guidelines outlined in Collaboration for Environmental Evidence (Pullin et al., 2018). To identify articles for review, I conducted keyword searches in the Web of Science Core Collection database from 2000 to 2019, including all countries. I adopted these broad initial criteria to identify relevant, peer-reviewed articles from any country. To conduct the initial article search I used search strings that paired a conservation subject with a marketing technique. "Conservation" subject keywords included environment, forest, natural resource, conservation, and wildlife. "Marketing technique" keywords included, marketing, advertising, market segmentation, nudge, social marketing, social network, message framing, communication. I deployed search operators, wildcards, and phrase searching, for example: "marketing", advertis*, "market segment*", nudg*, "social marketing", "social network*", "message fram*", communication, forest*, "natural resource*", conservation*, wildlife, nature, biodiversity. After an initial review of articles identified by the search, I appended the search by including the marketing keywords, "conservation marketing" and "social marketing" to ensure all conservation marketing-related articles were included.

Following initial search, I compiled articles identified by each keyword pairing combination in a master database that included the search terms used, journal title, year published, first author name, article title, and abstract for each article. Following all searches, I removed all duplicate articles from the database. Once all articles were compiled, I conducted a coarse title review to identify articles outside the field of conservation marketing.

To complete the coarse title review, I assigned each article title to at least two reviewers (i.e., faculty or fellow graduate students in the Human Dimensions Lab) who scored the title as either "0" which meant the article was not related to conservation marketing and should be excluded, "1" which meant the article

was related to conservation marketing and should be included, or "2" which meant the reviewer could not determine from the title if the article was or was not related to conservation marketing. For example, the title "Landscape Conservation: The Strategic Social Marketing Perspective" was included, whereas the title "Comparative Study of Random Forest and Neural Network for Prediction in Direct Marketing" was excluded. I excluded from further review only those articles which both reviewers scored "0." I then reviewed the titles and abstracts of all other articles (i.e., those scored "1," "2," or for which reviewers disagreed) and made a final inclusion/exclusion decision in consultation with my advisor.

Following this review, I created a database of conservation marketing literature that included the article title, publication year, first author location, study location, focal conservation issue, target audience (of the study, not the article), targeted behavior or outcome, study area scale, and marketing strategy used. Attribute values for each category were then aggregated following the rubric in Table 1. For example, in one study I initially identified the target audience as "eastern Burkina Faso agricultural producers," which was secondarily summarized as "rural farmers," and assigned the final target audience attribute of "individuals".

Table 1 Final conservation marketing article attributes, their definitions, and subcategories included in each.

CATEGORY	DEFINITION	SUBCATEGORIES

Issue	Conservation issue studied in article.	• Biodiversity
		  ○ Biodiversity
		  ○ Protected area management
		• Climate
		  ○ Climate
		• Resource Consumption
		  ○ Energy conservation
		  ○ Forest management
		  ○ Natural resource management
		  ○ Water conservation
		  ○ Land management
		  ○ Other conservation issue(s)
		• Wildlife
		  ○ Recycling, composting, etc.
		  ○ Human wildlife conflict
		  ○ Illegal wildlife trade
		  ○ Marine conservation
		  ○ Species conservation
		• Conservation Marketing*
		
		* papers that discuss marketing applications to conservation issues

Target Audience	Target audience studied in article or intended audience for the article.	● Individuals ○ General public ○ Homeowners ○ Hunters ○ Landowners ○ Low-income residents ○ Residents ○ Rural farmers ○ Tourists ● Organizations ○ Businesses ○ Conservation practitioners (non-profit organizations) ● Decision Makers ○ Local government ○ Natural resource managers ● Policy makers ○ Researchers ○ Academics
Objective Outcome	Objective outcome of study subjects (target audience).	● Behavior adoption ○ Technique adoption ● Behavior change ○ Conservation intention ● Behavior reduction ○ Conflict reduction ○ Demand reduction ● Cognition ○ Awareness ○ Decision making ○ Engagement ○ Value orientation ○ Willingness-to-pay ○ Motivation ● Collaboration ○ Collaboration ○ Stakeholder identification ● Knowledge production ○ Data collection ○ Information communication
Scale	Scale of study.	● Micro ○ Businesses/organizations ○ Community ○ Municipality ○ Protected areas ● Meso ○ Country ○ Regional ○ State ● Macro ○ Global
Marketing Strategy	Primary marketing technique used in the study.	● Segmentation, Targeting, Positioning (STP) ○ Community-based social marketing ○ Literature review ○ Marketing technique ○ Microtargeting ○ Segmentation ○ Social network analysis ○ Targeted communication

		● Delivery Tactic ○ Choice experiment ○ Communication channels ○ Gamification ○ Social media networks ○ Survey/interviews ○ Campaign ○ Advertising ● Messaging ○ Impact evaluation ○ Incentive ○ Message framing ○ Nudge ○ Psychological behavior change methods ○ Social norms ○ Value orientation ○ Appeal ○ Branding

Following attribute aggregation, I summarized the proportion of all articles across each category and calculated cross-tabulations of articles across each combination of all categories.

RESULTS

The initial search yielded 775 articles. The coarse title review eliminated 441, leaving 334 articles. The abstract review eliminated another 156, reducing the final number of conservation marketing articles to n=178 since 2000 (Figure 3).

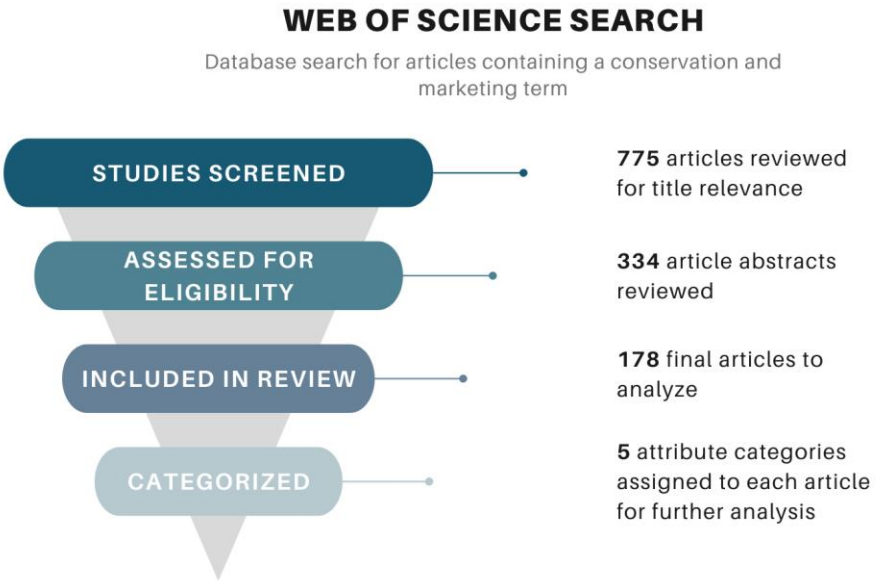

Figure 3 Web of Science database search for articles containing conservation and marketing term(s) process flow diagram.

Conservation marketing articles have become increasingly popular over the past two decades, increasing from 0–4 per year in the early 2000's to over 30 per year in 2018 and 2019 (Figure 4). An average of 8.7 articles were published over the last ten years from 2000 to 2019. First authors of conservation marketing articles hailed from 33 different countries. First authors from the United States (USA) led a plurality of articles, accounting for 57 of the 178 papers, or 32% (Figure 4). Most papers, however, were published by non-USA first authors (68%) at a rate of about 8 articles per year over the past 20 years, compared to the USA authors' rate of about 4 articles per year.

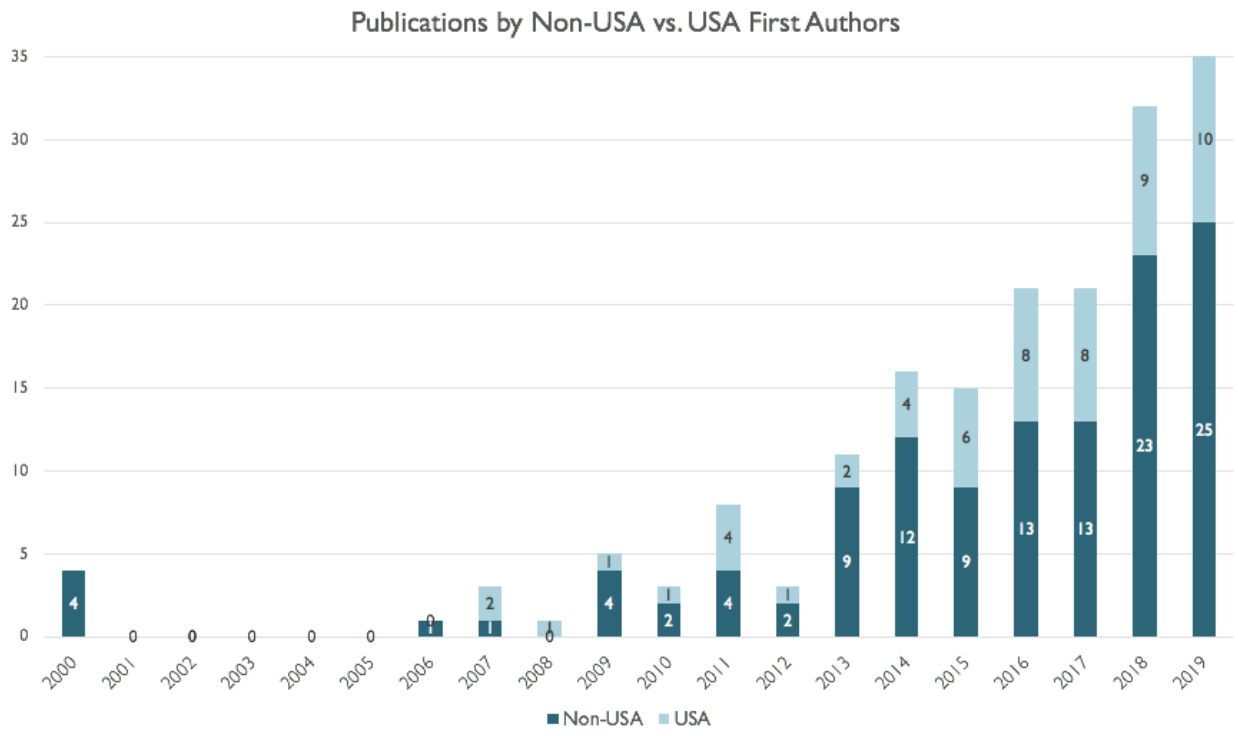

Figure 4 The number of conservation marketing publications by Non-USA vs. USA first authors from 2000 to 2019.

About a quarter (n=41; 23%) of the articles reported results from study areas located in countries other than the home country of the first author (Figure 5). For example, the United States first authors represented 31% of the total studies (56 total articles), of which 20% (11 articles) were conducted outside the US (Figure 5). Germany's first author studies represented about 6% of the total studies, and 40% of those studies were conducted in Germany, the other 60% of study sites were in countries such as Ethiopia, Indonesia, and South Africa. Austria (100%), France (100%), the Netherlands (100%), Portugal (100%) and Spain (50%) also had a majority of their studies conducted in a country that differed from their first author's home country.

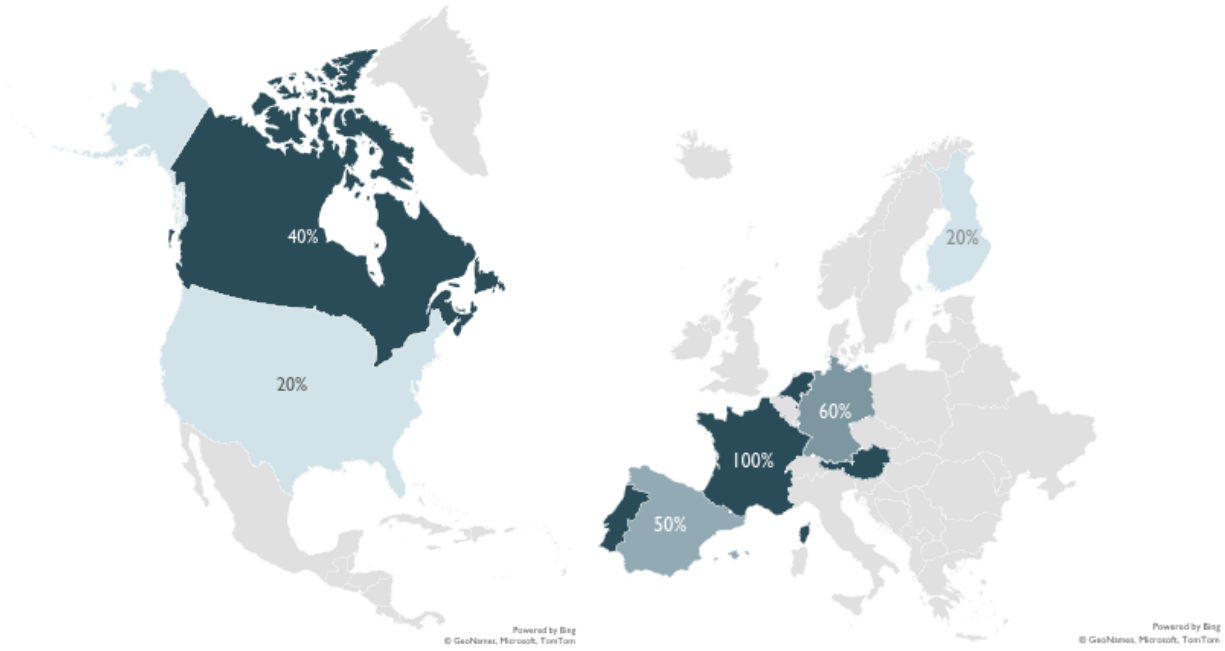

Figure 5 Countries of the world, shaded to indicate the percentage of conservation marketing articles published by a first author from that country with a study site outside that country[1].

Results demonstrated that the majority of conservation marketing articles (48%) focused on resource consumption, followed by wildlife (29%), and biodiversity (15%). A small number of conservation marketing papers discussed conservation marketing itself (6%). Very few conservation marketing articles focused directly on climate (3%) (Figure 6).

[1]Percentages depicted by the map legend include Austria (100%), Canada (40%), England (32%), Finland (20%), France (100%), Germany (60%), Netherlands (100%), Portugal (100%), Spain (50%), and the United States (20%). Not shown on the map: Australia (19%), Japan (33%), South Africa (20%). Countries shaded gray did not have any first authors of conservation marketing articles.

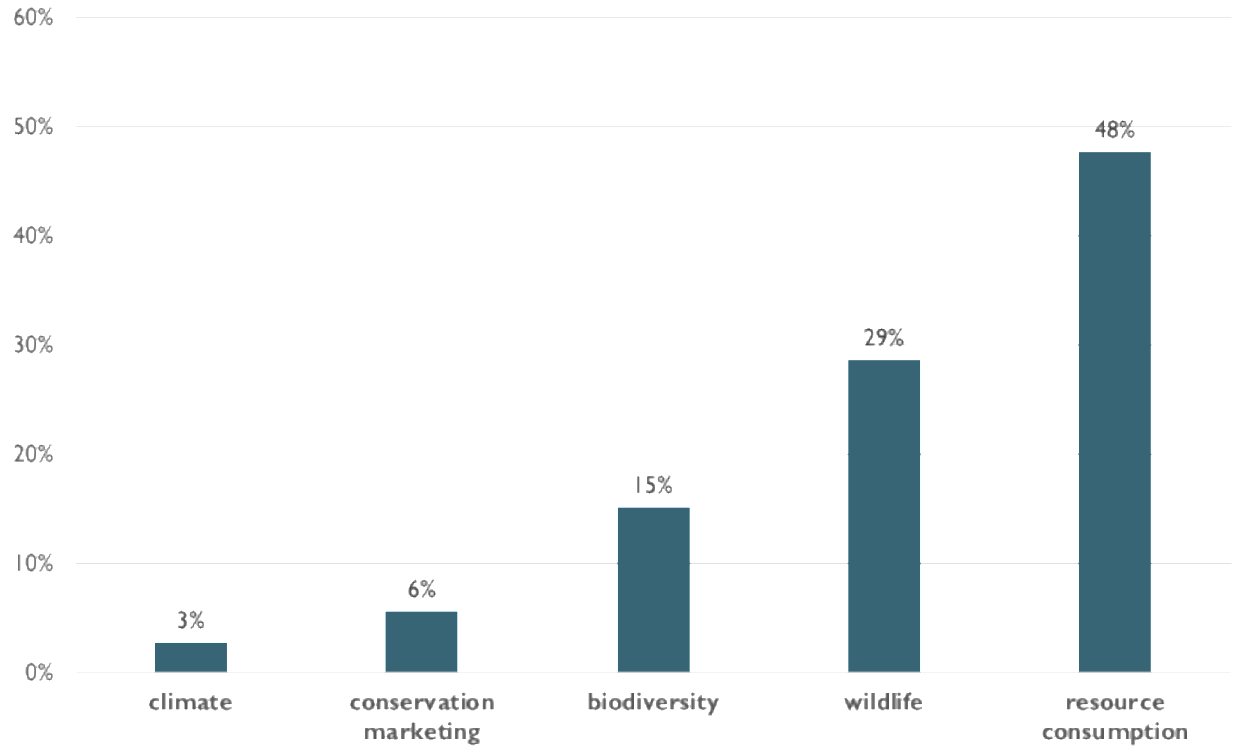

Figure 6 The percentage of conservation marketing articles (total n=178) by conservation issue.

Within each environmental issue, the proportion of USA first authors to non-USA first authors differed somewhat. Of the 51 papers on wildlife, 65% were by non-USA first authors and 35% by USA first authors (Figure 7). Resource consumption category had the same split with 65% of articles by non-USA first authors and 35% by USA first authors. Seventy percent of the conservation marketing focused articles were led by non-USA authors and 30% by authors from the USA. Of the 5 papers in climate, 80% were by non-USA authors and only 20% by USA first authors. The biodiversity issue category had the most discrepancy between non-USA first authors (85%) and USA first authors (15%).

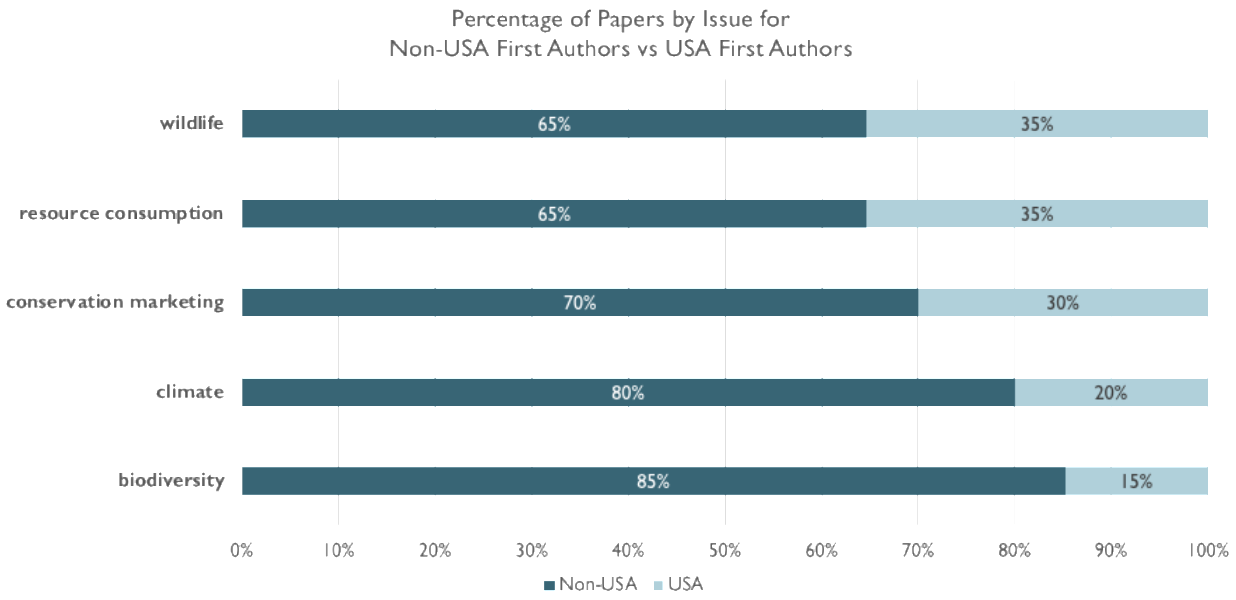

Figure 7 The percentage of articles written by USA and non-USA first authors within each conservation issue category.

In part because of the limited focus on climate change among conservation marketing articles, I re-examined the resource consumption sub-categories to provide more detailed proportions of focal issues (Figure 8). I found that just over one fifth of studies in the resource consumption category focused on energy conservation (22%) which could potentially be confounded with climate change mitigation efforts (but also could not), followed by forest management (20%), other conservation issue(s) (18%), water conservation (15%), land management (13%), and natural resource management (12%). If I assume all energy conservation focused articles were directly or indirectly about climate change, they would account for an additional 10.5% of all conservation marketing articles, or a total of 13.5% when combined with the 3% of conservation marketing articles focused explicitly about climate change (see Figure 6 for comparison).

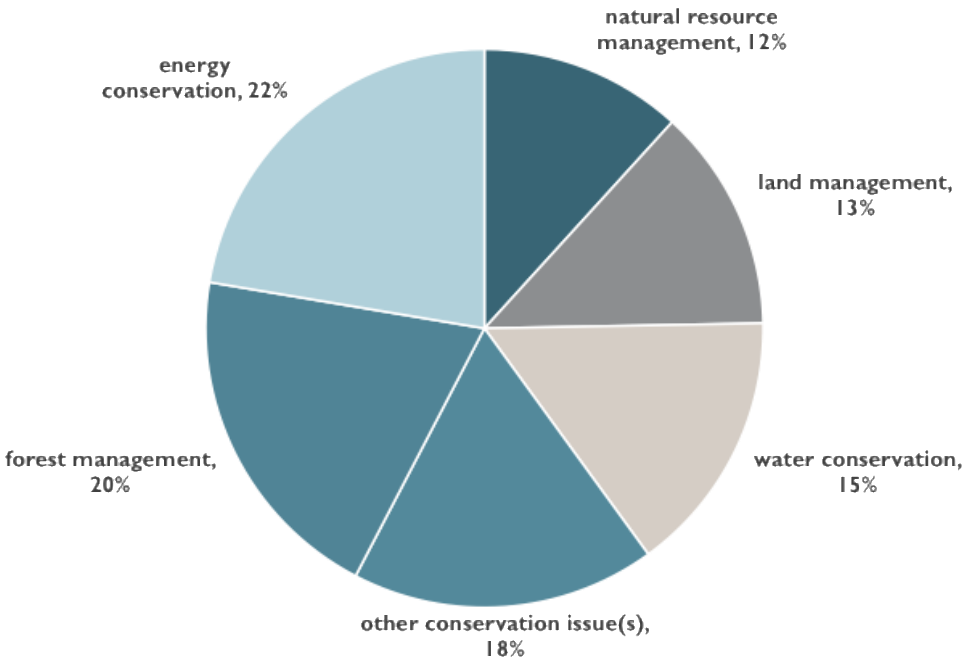

Figure 8 Resource consumption sub-categories.

Results indicated that the majority of conservation marketing efforts (56%) sought to change the behaviors or cognitions of individuals (Figure 9). About one third of studies targeted organizations for change, while the remainder sought to influence researchers (11%) or decision makers (7%).

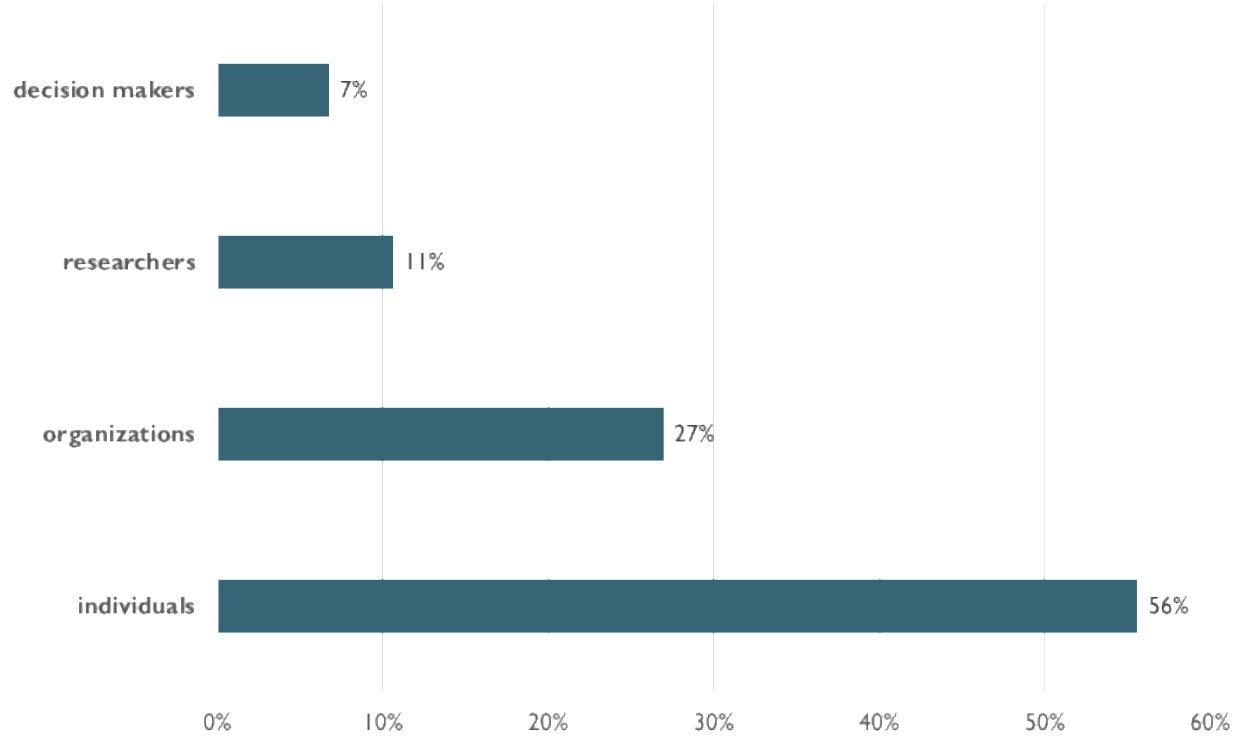

Figure 9 The percentage of conservation marketing articles (total n=178) by target audience.

The objective outcome sought by conservation marketing studies included awareness/knowledge, cognitions, and a variety of behavior changes. Although cognition was the focus of one quarter of conservation marketing articles (25%), the plurality of studies sought to influence behavior, either through behavior reduction (17%), behavior adoption (16%), or behavior change (14%), representing a sum total of 47% of articles (Figure 10). Knowledge production made up about 17% of objective outcome actions. A small number of studies sought to inspire collaboration (10%).

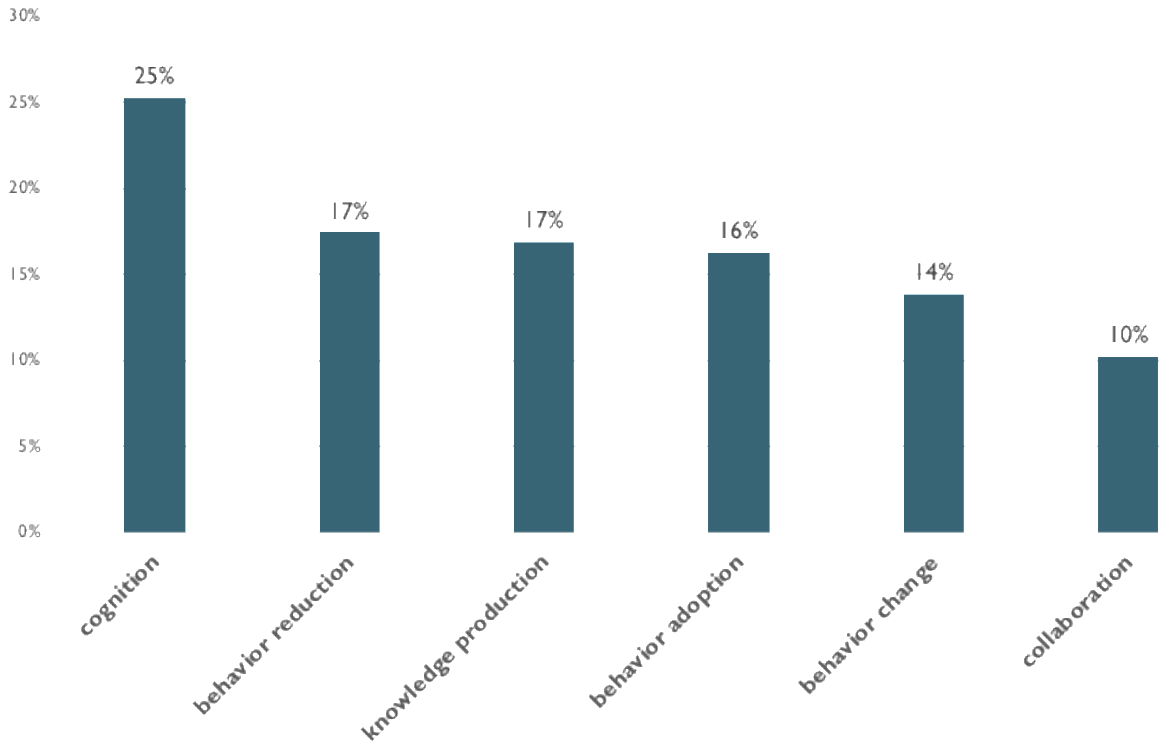

Figure 10 The percentage of conservation marketing articles (total n=178) by objective outcome.

The plurality of articles reported study sites at the micro scale (43%), whereas meso and macro scales were each represented by 29% of the studies (Figure 11).

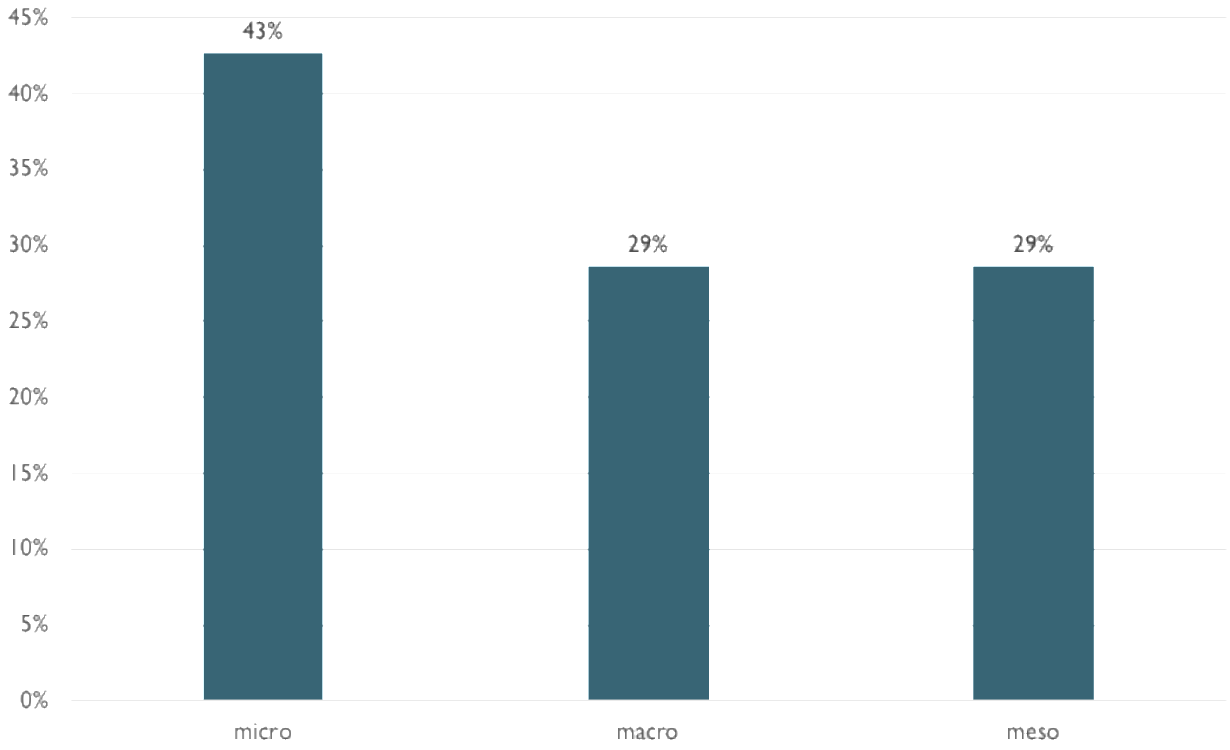

Figure 11 The percentage of conservation marketing articles (total n=178) by scale.

About one third of studies focused their marketing strategy on segmentation, targeting, positioning (34%), followed by messaging (30%), and delivery tactics (29%). The Conservation marketing discussion strategy category was the least represented in the studies (7%) (Figure 12).

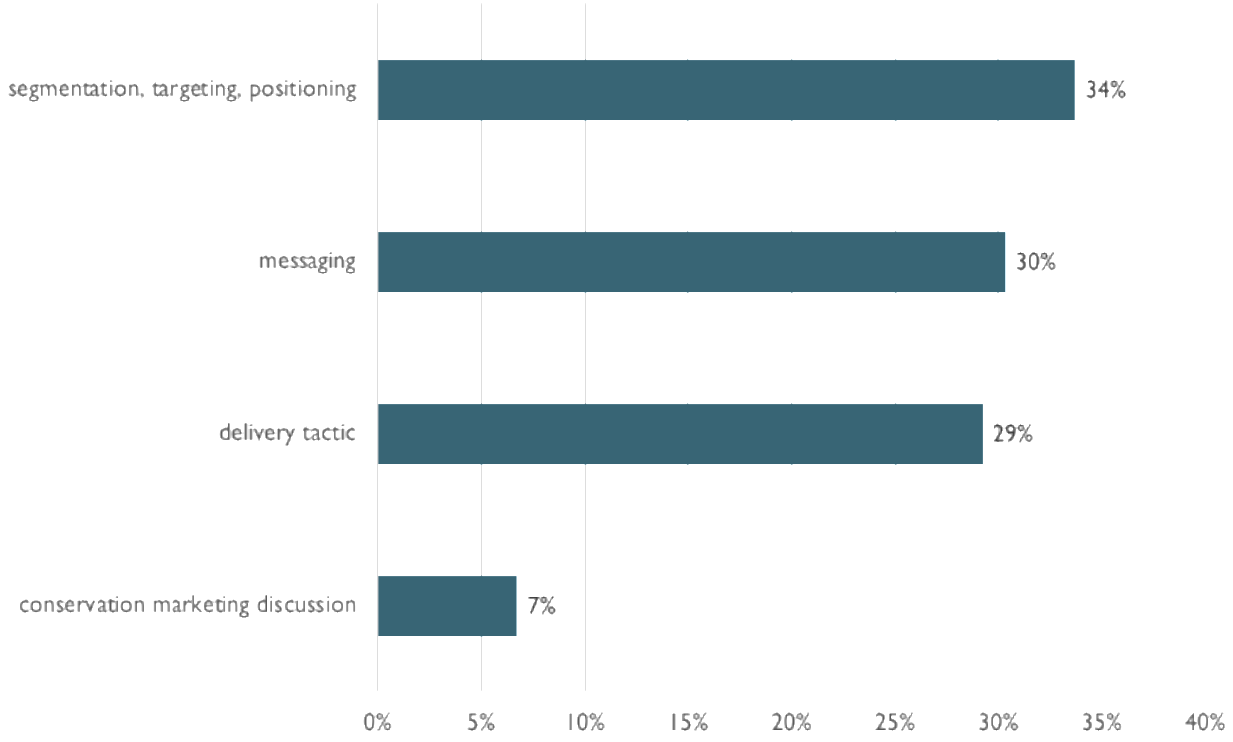

Figure 12 The percentage of conservation marketing articles (total n=178) by marketing strategy.

I conducted several crosstabs of article variables, including two shown below and four more available in the Appendix C. Those available in the appendix did not yield additional insights; that is to say, overall patterns revealed by the crosstabs were consistent with patterns shown in the univariate summaries above. The two crosstabs that did provide additional insights were conservation issue by scale, and target audience by issue, each described below.

Results showed that focal issues of conservation marketing articles appeared to differ across scale (Figure 13). For instance, studies at the micro scale were more frequent and dominated by resource consumption issues followed by wildlife, biodiversity, and climate. At the meso scale level, however, resource consumption was less popular (although still dominant) with wildlife, biodiversity, and climate representing a greater proportion of studies. At the macro scale, resource consumption was even less frequent a focus than wildlife and was only slightly more common than biodiversity.

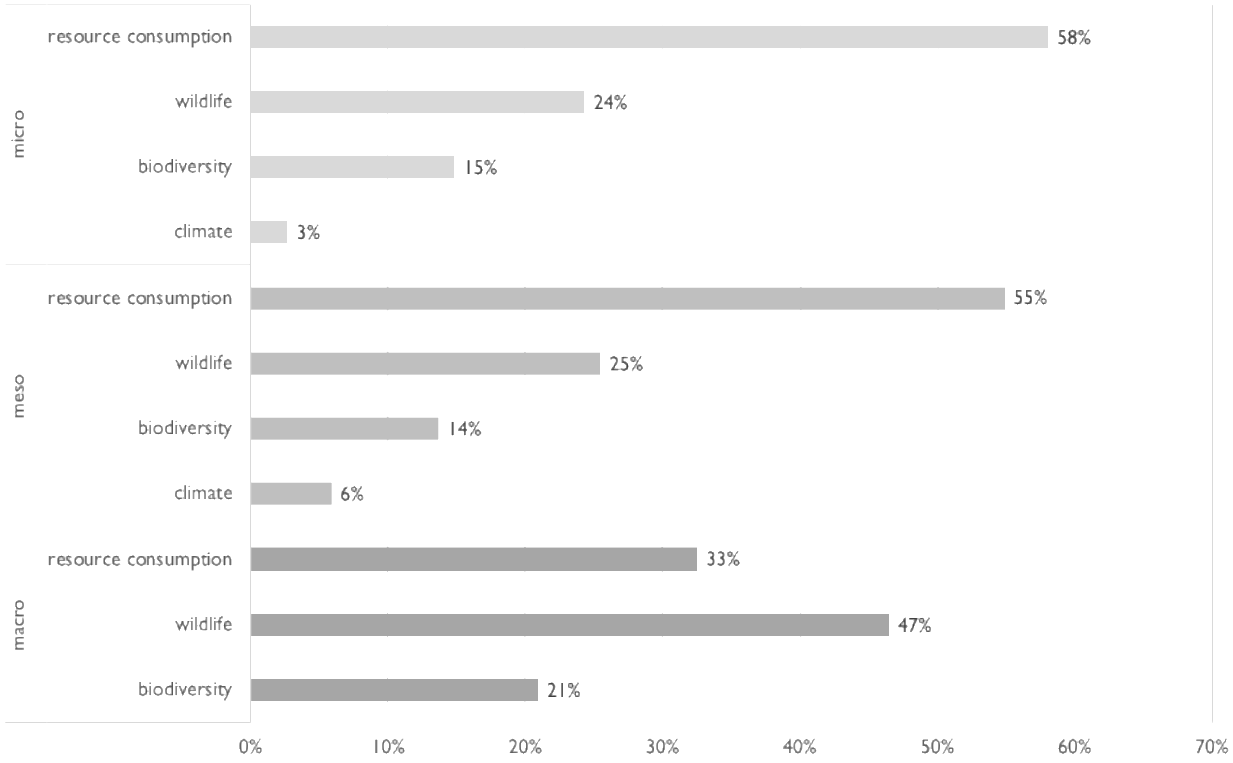

Figure 13 Conservation Issues by Scale crosstab.

The predominant target audience varied among the conservation issues of focus (Figure 14). Two thirds of studies that focused on resource consumption targeted individuals (66%), followed by about one-quarter targeting organizations. Very few studies focused on resource consumption targeted researchers (6%), and very few targeted decision makers (2%). Studies that focused on wildlife again targeted individuals as the majority (59%), organizations, decision makers, and researchers made up a greater proportion of wildlife studies (41%) compared to those focused on resource consumption (34%). Biodiversity studies were less targeted toward individuals, comparatively (though still the plurality at 44%), with organizations, decision makers, and researchers representing a majority of these studies (56%). Climate focused studies did not target researchers (0%), but instead targeted individuals (20%) and organizations and decision makers to a far greater degree (80%).

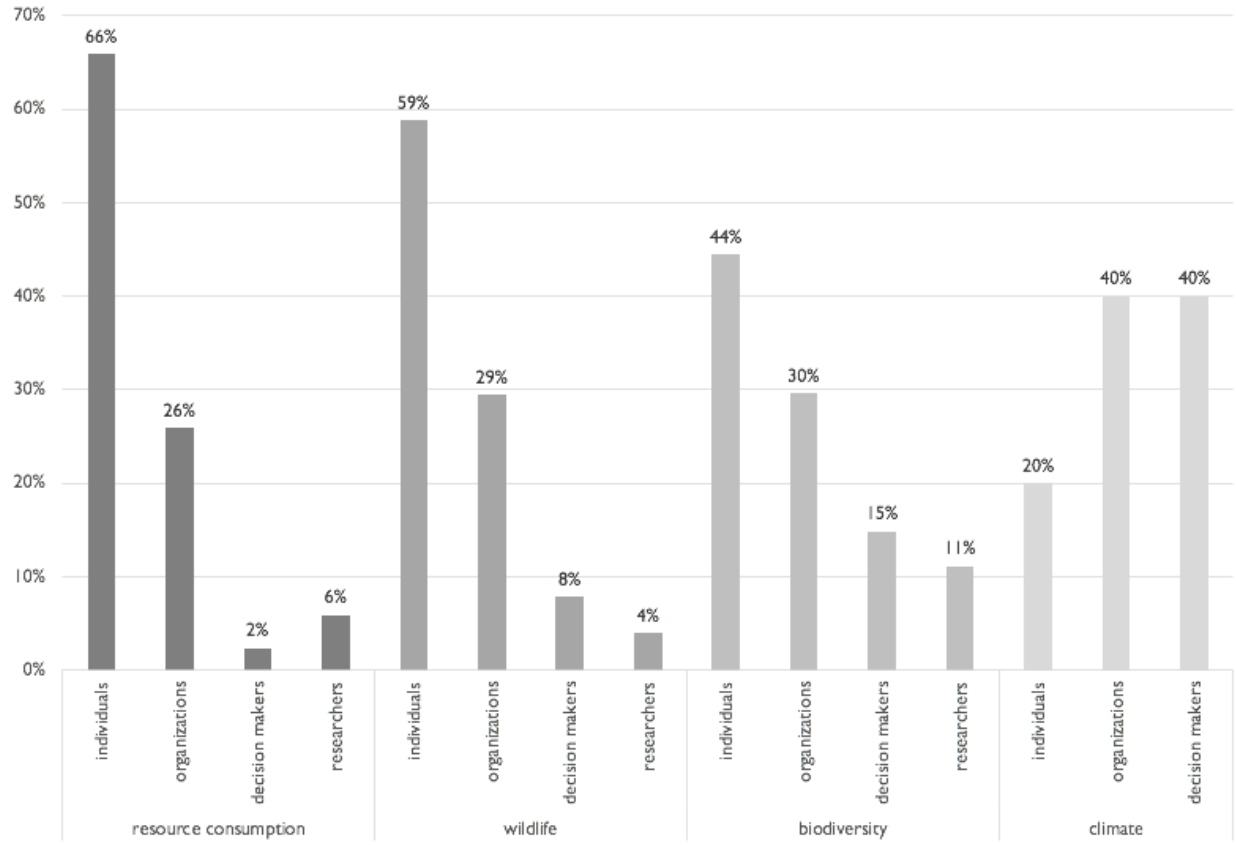

Figure 14 Target Audience by Issue crosstab.

DISCUSSION

Conservation marketing is increasing in popularity among academics and researchers, as evidenced by the growing number of papers published on the topic over recent years (Figure 4). USA first-authored papers are increasing slowly, whereas non-USA authored papers are driving more of the growth in conservation marketing research in recent years (Figure 4). A deeper dive into the issues studied by non-USA vs USA first authored papers reveals that most topics are evenly distributed except for biodiversity which is more of a focus for authors outside the USA (Figure 7).

The international nature of conservation marketing extends to study sites as well, with over one-fifth of studies representing study sites outside the first author's country (Figure 5). In Germany, Austria, and Portugal, the majority of conservation marketing research took place outside of the first author's own

country. This is encouraging as it suggests conservation marketing is not solely limited to Western, educated, industrialized, rich, and democratic (WEIRD) samples (Henrich, Heine, & Norenzayan, 2010) which is good for the generation, testing, and spread of ideas.

Despite the international nature of authors and study sites, conservation marketing may be failing to address biggest international conservation issue: climate change. Most articles focused on the conservation challenges addressed by resource consumption which are perhaps the most obvious opportunities for marketing to influence because they are caused, and potentially solved, by individuals' behaviors (e.g., energy conservation, forest management, water conservation, land management, natural resource management and other conservation issues). Remaining articles focused on biodiversity, wildlife, and climate. Climate represented just 3% of articles' explicit focus (Figure 6), or 13.5% if I assume articles focused on energy consumption were at least indirectly related to climate change. These results demonstrate a clear opportunity for conservation researchers to more thoroughly explore how marketing techniques might influence the existential threat of climate change. Whether future conservation marketing studies seek to address climate change mitigation directly, or through individual resource consumption of water or energy, there is much room for increased attention on how marketing techniques might help advance climate change mitigation and adaptation goals. Conservation marketing wishing to focus more directly on climate change should be mindful that many people do not feel like they experience the effects of climate change on a daily basis (Spence, Poortinga, Butler, & Pidgeon, 2011), although this could have changed in recent years. Further, conservation marketing research thus far has tended to focus on individual behaviors, rather than institutional decision-making, the latter of which may be more necessary for addressing climate change. But conservation marketing can be oriented toward inspiring institutional change as well as individual behavior change by targeting decision-makers rather than individuals or encouraging individual behaviors such as voting or calling elected representatives to urge action on climate change. I encourage conservation marketers to creatively explore

these and other opportunities to leverage the field to more effectively address the world's most challenging conservation challenge.

I found a small, but promising foundation for future climate change work in the conservation marketing literature. Among the few climate-related conservation marketing studies that I did find, researchers explored how to motivate organizations and decision makers rather than individuals (Figure 14). The need for expanded work here is critical, as evidenced by a recent study that found 100 companies are responsible for 71% of global emissions (Griffin, 2017). Conservation marketing research focused on inspiring these companies and the individuals who run them to reduce emissions, could have outsized impact on this global issue. Conservation marketing clearly has an opportunity to better answer the loud and growing call for climate solutions (Jamal & Watt 2011; Streimikiene 2015; Valatin, Moseley, & Dandy, 2016).

Not only is there an opportunity for the conservation marketing field to focus on bigger issues like climate, but also to evaluate focal scales which might expand the field's influence (Figure 13). Studying individuals is useful if you can turn it into collective action, as many conservation issues cannot be solved from an individual capacity, but instead require a larger scale movement (Smith et al., 2010; Wright et al., 2015; Veríssimo, & Mckinley, 2016; Veríssimo, & Mckinley, 2017). The conservation marketing field could benefit from expanded scales of focus, enlarging the potential impact of insights gained through these research efforts.

Studies targeted toward individuals that focused on resource consumption and wildlife made up the largest segment of conservation marketing articles. Resource consumption appears to be the first place researchers "think" to apply conservation marketing. This is unsurprising as advertising campaigns most familiar to us include those that use social norms or product packaging to encourage recycling, turning off of lights when we leave the room or the faucet while we brush our teeth, and use fewer paper products (McKenzie-Mohr, 1994; Foxall et al., 2006; Smith, 2010; Sheau-Ting, 2013; Wright et al., 2015;

Veríssimo, 2019). Many conservation marketing campaigns use flagship species to appeal to individual consumers/conservationists (Veríssimo, MacMillan & Smith, 2011; Hayden & Dills, 2015; Macdonald et al. 2017; Veríssimo et al., 2017; Santarém, 2019). Animals have been successful at creating conservation engagement and behavior change when used in campaigns either for outreach or awareness (Hayden & Dills, 2015; Macdonald et al., 2017; Veríssimo et al., 2017; Burton, 2018; Santarém, Pereira, Saarinen, & Brito, 2019).

Perhaps in part because of the dominating focus on individuals in the conservation marketing literature, researchers are missing an opportunity to inspire change at institutional scales. This may because research on individuals is far more accessible than research on larger audiences such as organizations, research groups, or decision makers. Decision makers were the least targeted audience and seem like another opportunity for conservation marketing research to expand its focus and impact given that decision makers are often in positions to most effectively address big conservation issues and initiate policies for change (Dovers & Hezri, 2010; Berman, Quinn, & Paavola, 2012). Although common perceptions of marketing include an outsized focus on individuals, there is a large body of literature about how to market to "firms," including how they make strategic decisions, how they compete, etc., that would be interesting to engage as conservation marketers explore how campaigns might seek to change "firm" behavior to promote conservation outcomes (Avram & Kühne, 2008; Nye & Hargreaves, 2010; Vázquez-Carrasco, & López-Pérez, 2013; Engert, Rauter, & Baumgartner, 2016).

Conservation marketing literature does an excellent job, however, of focusing on actual behaviors rather than being content with target variables such as "attitudes" or "behavioral intentions" (Figure 10). This is important because behaviors, not simply cognitions, are key for solving conservation issues (McKenzie-Mohr 2000, 2011, 2012; Schultz 2011). Cognitions are also common, which may be important antecedents to change (Smith et al. 2010; Wright et al.,2015; Veríssimo et al. 2018), but future authors could benefit from clear linkages between focal cognitions and desired outcomes and establish those

connections with evidence (Acciaioli & Afiff 2018; Olmedo, Sharif, & Milner-Gulland 2018; Veríssimo et al. 2018; Salazar, Mills, & Veríssimo, 2019; Veríssimo & Wan 2019).

Marketing strategy was, for the most part, evenly distributed across strategies (Figure 12). Segmentation, targeting, positioning (STP) is the bread and butter of marketing, so it follows that it is the most used strategy within the conservation marketing realm. Conservation marketing discussion papers noted a lack of use of marketing techniques and strategies in conservation (McKenzie-Mohr 2000; Veríssimo & Mckinley 2016; Veríssimo & Mckinley 2017). These authors encouraged a call-to-action for conservation researchers to adopt these strategies (Veríssimo & Mckinley 2016; Veríssimo & Mckinley 2017; Green, Crawford, Williamson, & DeWan 2019; Veríssimo 2019). Our review suggests authors are beginning to heed this call and, in fact, there is demand among academics for training across a broad suite of conservation marketing skills (Robinson, Creasey, Skeats, Coverdale, & Barlow 2019).

Future research on the conservation marketing literature could benefit from a wider search criterion of referred literature, and the inclusion of gray, or unpublished, or non-peer-reviewed literature. I identified articles for this review using the Web of Science Core Collection Database, which is not an exhaustive search of all available journal databases, so some conservation marketing relevant articles could have been missed. Further, although the articles I found could have come from first authors in any country, only those published in English were included in my review which may have excluded important literature lacking an English translation. I also did not include an analysis of co-authors which may obfuscate some connection between home country and article focus. Although many studies were conducted internationally, this hints at some limitations to the analysis — do we really know the nature of the samples in the studies? Does international really mean not Western, educated, industrialized, rich, and democratic (WEIRD)? Lastly, many non-academic conservation marketing campaigns are driven by non-profits and agencies whose methods and results may not be published in referred journals. Despite the lack of peer-review, there may be much to learn from the gray literature about the extent and nature of the

conservation marketing field, as well as behavioral insights more widely relevant to the conservation community.

CONCLUSION

Conservation marketing has grown in popularity over the past two decades in ways not previously summarized or understood comprehensively. To document the nature of conservation marketing contributions to date and provide direction for future research investments in the field, I conducted a systematic review mapping exercise of the conservation marketing literature from 2000–2019. My review of the conservation marketing literature from 2000–2019 shows a strong focus on resource consumption and wildlife-related behavior change among individuals at small scales. These observations reveal clear opportunities for conservation marketing researchers to expand their inquiry toward more diverse pathways of change and across a wider array of conservation issues, most notably climate change and a greater investment toward institutional, in addition to individual, behavior change.

This review highlights how conservation marketing has oriented itself to conservation issues and the opportunities that remain for the field to explore in more depth. For example, a majority of conservation marketing articles focused on individuals rather than institutions or decision-makers, with the goal of some behavioral action related to resource consumption at relatively limited spatial scales. I believe conservation marketing has far more potential to influence different actors, at wider scales, and with respect to a wider array of conservation issues.

There is a lot of potential for conservation marketing targeted at different audiences, different issues, different scales, and different types of behavior change. Instead of following assumed applications of marketing to conservation, such as individual behavior changes through advertisement, I believe the field could benefit from a problem-oriented shift in focus. That is to say, conservation marketers could orient their research on the biggest conservation problems facing society and use analyses of these pressing issues to identify most effective target audiences (e.g., perhaps decision-makers rather than individuals)

and the most needed changes (e.g., perhaps policy rather than consumerism). Marketing theories and techniques present an opportunity for conservation advocates. Currently those advocates and scholars are just scratching the surface. There is no systematic approach to conservation marketing and the current focus is mis-allocated — too much attention on individuals and not enough on institutional actors, and far too little focus on climate change. Our big conservation issues, especially climate issues, will not only take individual and collective action, but necessitate the participation of decision and policy makers, as well as organizations and corporations. This review highlighted that glaring gap and exciting opportunity.

There seems to be a large opportunity to apply conservation marketing to non-individuals, like organizations and decision makers, which may also include funders. The lack of publications with these foci could simply be a product of organizations not publishing results from their conservation marketing efforts. Notoriously, publishing in peer-reviewed journals requires the advancement of theory, not just applications or campaign successes. These publication incentives along with concerns over proprietary information may be preventing researchers and practitioners from more widely sharing discovered solutions to globally pressing conservation problems. There also appears an opportunity to apply existing marketing expertise in the non-profit world to conservation outcomes, rather than simply fundraising or membership drives. Regardless, the conservation marketing world is growing rapidly, and the field will likely benefit from an intentional approach to our research and application of marketing strategies for conservation success. It is my hope that the review I've presented here is but one first step in that direction.

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Chapter 2

Estimating Landowners' Propensity for Conservation Easements Across Large Landscapes Using Data Analytics.

INTRODUCTION

Land conservation in the American West is becoming increasingly important as our population continues to grow, and development expands (Robbins, 2020). Private lands, where the vast majority of this expanded development is occurring, represent some of the most productive lands and habitat, and are often critical for providing access to public lands. Conservation easements are a legal tool that can be used to prevent habitat fragmentation and restore connectivity often disrupted by private land ownership and development patterns. Currently, efforts to prioritize the placement of easements tend to focus on the biophysical characteristics of parcels, rather than the receptivity of landowners to establishing easements (e.g., Naidoo et al., 2008; Kukkala & Moilanen, 2017; Kujala, Moilanen, & Gordon, 2018). Efforts to incorporate landowner receptivity measures have been limited by data availability and analysis techniques (Whitehead et al., 2014; Nielsen, Strange, Bruun, & Jacobsen, 2017; Paloniemi et al., 2018).

To solve this problem, I, along with the help of the University of Montana Human Dimensions Lab, developed three models predicting landowner propensity to participate in a conservation easement. The modelling approach I adopted allows me to estimate easement propensity scores for nearly every individual landowner in the state of Montana at relatively low cost. Using a combination of landownership data, conservation easement records, and publicly available consumer data, I performed several analytics calculations, commonly used in the marketing field, to generate easement propensity scores for private landowners statewide. Validation tests showed the final models were 1.79–1.86 times better at identifying landowners interested in easements than a model with no covariates (i.e., random). The approach I describe here has the potential to dramatically reshape conservation easement

prioritizations and enable greater return on investments and efficiency for myriad conservation organizations.

BACKGROUND

Approximately 65% of the 2.27 billion land acres in the United States are owned by private entities (Theodore Roosevelt Conservation Partnership & OnXMaps, 2018; Congressional Research Service, 2020). Private lands are generally the most biophysically productive, disproportionately used by wildlife, and more likely to be found along waterways, making them indispensable pieces of the conservation puzzle (Bolle & Taber, 1962; Robinson, Allred, Naugle, & Jones, 2019). For instance, according to a study on western rangelands where human population growth far exceeds the national average, rural land in the West is being converted to development at an average rate of 2.32 percent annually (Charnley, Sheridan, & Sayre, 2014). This same study noted that private non-industrial forestlands are increasingly being sold and managed as investment properties, leading to parcelization (i.e., ownerships divided into smaller parcels) making uncertain their future conservation and land-use status (Charnley, Sheridan, & Sayre, 2014). The private lands bordering public lands are often the most at risk of being developed due to elevated amenity values and recreational opportunities (Hansen et al., 2002). Private lands adjacent to public lands are also key for enabling public access to public lands in addition to providing disproportionately high conservation value.

Figuratively and literally, the United States has a checkered history of land ownership and land-use. Land has been divided and disposed of for the purposes of railroad construction across the country, exploration and exploitation of new lands, settlement, and to reduce the national debt from the Revolutionary War (Rasband, Salzman, Squillance, & Kalen 2016). Many of these decisions were made without future environmental implications in mind, such as ecosystem management, land access, wildlife connectivity, forest management, wildfire management, and watershed protections (Powers 1982; Franklin & Foreman 1987; Mattson & Merrill, 2002; Aguilar, Ashworth, Galetto, & Aizen 2006; Zavaleta et al. 2009; Busby,

Albers, & Montgomery 2012; Proctor et al. 2012; Guttery et al. 2013). Following the Louisiana Purchase, the US Government used land disposal as a means for paying soldiers, reducing the national debt, strengthening the nation, and encouraging transportation, development, and settlement of the West (Congressional Research Service 2020). In the American West, the Jeffersonian Survey System was used to survey land from a single point, or meridian, into 36-square-mile townships. Each township was divided for sale into lots/sections that were one-mile square, each containing 640 acres, creating a checkerboard-like pattern of land division (Figure 15).

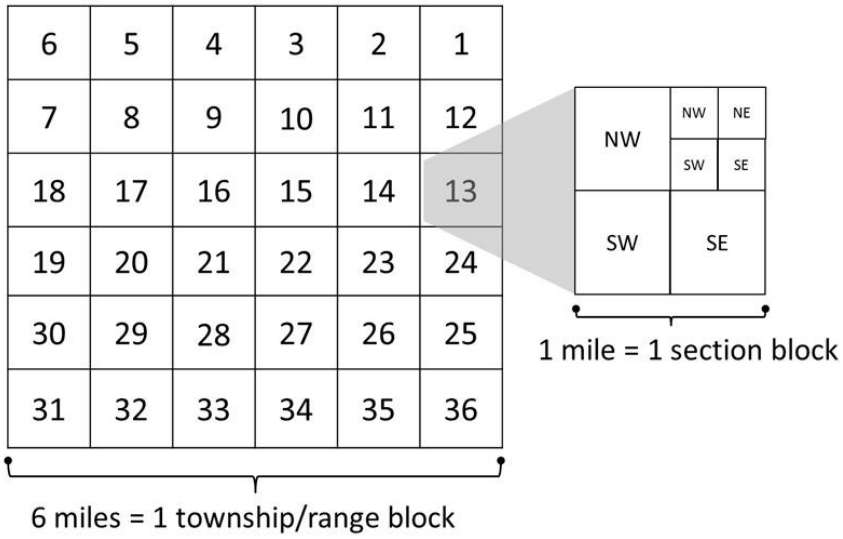

Figure 15 Sample Township divisions, courtesy of https://history.fcgov.com/farms/

As each state joined the Union, they were granted ownership of one section of land— then later two sections, and finally four sections— of each township, to be used in a manner which supported education and other state institutions such as universities, penitentiaries, asylums, and hospitals (Rasband et al. 2016). In areas where rail construction was desired, each odd numbered section in the township was often given to a railroad company, with even numbered sections retained by the federal government. The reasoning behind dividing the land this way was the thought that railroad access would promote westward development and increase the value of the land both for the railroad companies and for the federal government, thus ensuring quality rail construction (Rasband et al., 2016).

In addition to states receiving land from the federal government, a series of land grants also benefited private settlers, primarily through the Homestead and Preemption acts (Dana & Fairfax 1980). These acts allowed any family head who was a citizen of the United States, or had declared an intention to become a citizen, to be given free title for up to 160 acres of land provided they lived on it for five years, paid fees, and cultivated the land (Dana & Fairfax 1980). This further divided the land and exploited its resources. This division of land has complicated public land managers' capacity to manage public lands that have been landlocked (i.e., surrounded by private parcels) and the public's ability to access public lands (TRCP & OnXMaps, 2018).

Often unmentioned in the telling of this history is the fact that these lands were not only acquired from the original colonized states and European powers, but from the Indian tribes who had populated the continent prior to European arrival. The history of the United States' dealings with Indian tribes is complicated and full of injustice. Although I cannot cover those aspects here in this thesis, I would be remiss to not acknowledge these land takings and encourage all who work on land management issues to familiarize themselves with this history and seek ways to reconcile these transgressions (recommended reading list: *Bury My Heart at Wounded Knee, Trusteeship in Change: Toward Tribal Autonomy in Resource Management, Documents of United States Indian Policy, Blood Struggle: The Rise of Modern Indian Nations)*.

In addition to the humanitarian impacts of this history, the environmental impacts of land allocation to federal, state, and private entities remain an issue of contention today. In the United States, residential and commercial development is continuing to increase on these lands, encroaching on forests and agricultural land, and degrading rivers, lakes, and wildlife habitat (Benfield, Chen, & Raimi 1999). Urban sprawl is causing issues for ecosystem-management activities such as control of fire regimes, eradication of non-native species, and management of wildlife (Farmer, Knapp, Meretsky, Chancellor, & Fischer, 2011). Neither biological processes nor environmental phenomena respect conventional property lines, but

conservation efforts at the parcel level can aggregate to produce conservation outcomes as larger scales. One tool for achieving conservation outcomes on private land is conservation easements.

CONSERVATION EASEMENTS

A conservation easement is a negotiated, legally binding agreement between the individual(s) who owns property and a second-party organization such as a state or federal agency, or a nongovernmental organization such as a land trust (Farmer et al., 2011). The National Conservation Easement Database (2020) estimates approximately 40 million acres are currently privately owned conservation easements, which is about 1.76% of total US lands. Specific rights associated with landownership can be divided and sold (or donated) independent of one another. For example, a conservation easement can protect land in perpetuity from being subdivided and developed for residential or commercial activities or prevent the dumping of toxic waste and surface mining (Montana Association of Land Trusts, 2020). Other easements may allow public access or prohibit or require timber harvests. Negotiations between landowner and easement holding entities are frequently tailored to the unique character of the land and the conservation goals of all parties involved, such that easements can be heavily customized and vary widely in intent and purpose (Montana Association of Land Trusts, 2020). In Montana, state law requires a conservation easement accomplish at least one of three conservation purposes: 1) protection of open space (including farmland, ranch land and forestland), 2) protection of a relatively natural habitat for fish, wildlife or plants, or 3) protection of lands for education or outdoor recreation of the general public (Montana Code Annotated Section 76-6-203, Rev. 2019). Conservation easements are generally difficult to establish, requiring investments of money, time, and expertise, and frequently rely on trusting relationships to serve as the foundation for good faith negotiations.

For landowners, the trade-offs between property values and personal and environmental values can be challenging (Merenlender, Huntsinger, Guthey, & Fairfax 2004; Farmer et al. 2011; Farmer, Chancellor, Brenner, Whitacre, & Knackmuhs 2016; Stroman et al. 2017; Vizek, & Nielsen-Pincus 2017). Studies

have shown that placing a conservation easement can reduce the land value by up to 50% (Anderson & Weinhold 2008). In 2015, to help promote more conservation easements, Congress enacted one of the most powerful conservation measures in decades: the enhanced federal tax incentive for conservation easement donations (Conservation Easement Incentive Act of 2015). This federal tax incentive is one way to help landowners overcome the financial challenges of placing a conservation easement on their land. The federal tax law allows easement donors to deduct the value of a conservation easement donation from their income for federal income tax purposes, and/or incurring lower property taxes (Lindstrom 2011). For landowners with large estates who wish to pass their land onto the next generation, there are estate tax incentives for land conservation. Both of these tax incentives reduce the pressure to subdivide or sell land for development and seek to increase the retention of open space and provision of ecosystem services (Stroman et al. 2017).

Despite the use of conservation easements for over a century, only recently have studies explored landowners' attitudes and motivations to participate in easements (Farmer et al. 2011, 2016; Stroman et al. 2017). Several studies suggest the need for a comprehensive understanding of the individuals who participate in conservation easements to contribute to the effectiveness of land conservation (Merenlender et al. 2004; Farmer et al. 2016; Gruver, Metcalf, Muth, Finley, & Luloff 2017; Stroman et al. 2017). Understanding the landowners is just one half of this equation. Similarly needed, but understudied, are the needs and challenges of land trust organizations responsible for acquiring and maintaining conservation easements.

Whatever the reasons may be, land trusts, and other easement-seeking organizations have experienced a notable decline in donated conservation easements, requiring more to be purchased (J. Doherty, personal communication, April 4, 2019). Many conservation easements involving access must now provide supplemental incentives to landowners like litter management, fence maintenance, and installation of signage (J. Doherty, personal communication, April 4, 2019). Recruitment costs required for finding landowners to participate in conservation easements are high, increasing, and more and more dependent

on the right partnerships between the right people in the right places. With a large landowner population in the US who hold limited interest in easements— an estimated 2% of landowners have a conservation easement, and <2% of landowners are "likely" or "extremely likely" to participate in a conservation easement in the future (Butler et al., 2020) and few resources to support easement establishment, land trusts and other easement-seeking entities could benefit from prioritizations of candidate private land parcels. This is increasingly true with the recent passage of the Land and Water Conservation Fund (LWCF), which expands funding and access to those funds to support conservation easement acquisition.

Efforts in the literature to prioritize private lands based on conservation value are dominated by models employing biophysical and ecological variables. Most studies prioritize land using some form of ecosystem services or biodiversity value and their potential benefits to humans (Naidoo et al., 2008). However, most do not take into account social variables of the study area beyond the economic benefits to people (Naidoo et al., 2008). Kukkala and Moilanen (2017) argue that spatial prioritization for ecosystem services distribution must include aspects such as connectivity and spatial interactions between landscape elements, yet they fail to mention social receptivity to such conservation efforts. These studies focus on conservation prioritization but miss the mark when it comes to including social variables which might help explain where easements are likely or unlikely given the disposition of current landowners (Arponen, 2012; Kujala, Moilanen, & Gordon, 2018).

In recent years, efforts have been increasing to incorporate social variables into conservation prioritization efforts, however none have generated the wide-scale, fine-resolution data characteristic of their biophysical counterparts. Whitehead et al. (2014) completed a public participation survey to spatially represent social values, development preferences, and species distribution to determine areas of the landscape where different values converged or conflicted. Using stratified random sampling, they surveyed 395 participants to measure 11 social values to map over a region in concert with biodiversity features (Whitehead et al., 2014). Paloniemi et al. (2018) combined data from a landowner survey, spatial conservation prioritization, and stakeholder workshops to analyze how voluntary biodiversity

conservation could be used to target conservation actions. Both of these studies were conducted in areas where landownership data was readily available (Australia and Finland, respectively) and both used a survey or workshops to sample individuals and apply the results broadly to an area (Whitehead et al., 2014; Paloniemi et al., 2018). Although these studies both represent important advancements toward the inclusion of social variables in landscape prioritizations, they do not allow parcel-level estimates of whether a conservation action is likely or unlikely, relying instead on summaries of general social receptivity in an area to the hypothetical conservation of a particular ecosystem service or value.

One innovative study from 2017 did conduct a social analysis using a fine-resolution, wide extent approach more typical of biophysical prioritizations. Nielsen, Strange, Bruun, and Jacobsen (2017) built a propensity model of Danish landowners' willingness to participate in a voluntary forest conservation program using forest characteristics (e.g., area, production quality, number of hooved game shot in the region) and landowner characteristics (e.g., education, children in the household, number of co-owners, main occupation, age) as explanatory variables. With this approach, the authors were able to calculate propensity scores for 50,908 forest landowners in Denmark. Unfortunately, the data inputs for this model are rarely available at any wide extent outside of Denmark which may explain why this approach has not been replicated elsewhere, despite its innovative approach and useful outputs.

Here, I present a fine-resolution (i.e., parcel-level) prediction of conservation easement propensity among private landowners across a wide extent (i.e., State of Montana). To do so, I utilize a marketing tactic called “microtargeting,” which is typically used to effectively and efficiently target consumers of goods or services in a marketplace. Microtargeting uses a mix of data sources, such as purchasing patterns or voting history data, to identify individuals who are more likely to engage in a particular behavior or action such as purchasing a product or voting for a candidate (TechTarget 2019). This method has proven successful in the marketing of consumer goods (Kotler & Keller 2012; Sheau-Ting et al. 2013) and it is starting to emerge in conservation applications (Metcalf, Phelan, Pallai, Norton, Yuhas, Finley, & Muth, 2019; Metcalf, Angle, Phelan, Muth, & Finley, 2019). This powerful analytics tool may help

conservationists achieve more desired outcomes per resource investment by identifying prospects within a population who are already inclined to participate in conservation behaviors (e.g., easements).

Despite its promise for advancing conservation prioritization efforts, the utility of microtargeting for advancing conservation easements is untested and many questions remain. For instance, can microtargeting techniques generate useful predictions of landowners' willingness to place a conservation easement on their land or is this too nuanced a decision for this approach to detect? Do different modelling techniques generate widely different predictions of easement propensity and which method, if any, might perform best? With a case study in Montana, USA, I explore and answer these questions while building the first conservation easement propensity model for private landowners in a large, western US state.

METHODS

To develop the propensity model of landowner willingness for conservation easements, we compared and contrasted Montana private landowners with and without conservation easements to see which variables might predict easement propensity. For our analysis, we used individual landowner attributes from the Montana Cadastral Dataset (Base Map Service Center Montana State Library 2020) as well as voting and consumer attributes from publicly available data purchased from a private vendor (i.e., TargetSmart). We began by developing a dataset of current conservation easement holders in Montana. Montana is an opportune area for this study due to the availability of land ownership data via the Cadastral parcel database. The Cadastral parcel database stores information about public and private land ownership in Montana (i.e., total land value, total acreage, farm site acreage, forest acreage).

Conservation easement data is kept secure by land trust organizations; however, the National Conservation Easement Database (NCED) provides the boundaries for many conservation easements via download. In addition to the NCED database, the Cadastral also has a Montana Conservation Easement database with easement boundaries. Prior to analysis, we aggregated these two easement databases to

identify as many unique easement holders as possible without duplication (n = 468) before spatially joining the landownership data from the Cadastral database to the easement data.

We purchased consumer data for nearly all Montana residents from TargetSmart (n = 848,070), for $2,500 (US) and matched these data to the list of landowners in the Cadastral data (n = 451,722) with easement attributes using combinations of name and location, most frequently surname and ZIP code plus four. The TargetSmart database contained over 1,400 variables including demographics (e.g., age, gender), consumer behaviors such as media preferences and purchasing history, property-specific attributes (e.g., acreage, value of home, urbanicity), and hundreds of other variables about individuals' voting history, personal and commercial interests, etc. (see Appendix E for the complete data dictionary). We only included TargetSmart variables in our analyses if they had fewer than 35% missing data and were not duplicated by other fields (e.g., several entries for age, gender, address, etc.). After cleaning, this resulted in 447 usable variables from the TargetSmart database. We also cleaned the landowner data including dissolving duplicate owners (i.e., ensuring multiple parcels owned by the same person were represented by only one owner record), and removing commercial and public owners (e.g., churches, federal and state agencies, schools, hospitals, businesses etc.). Our final dataset included 461 variables on 180,933 individual Montana landowners.

We ran three separate propensity models on the dataset attempting to identify easement holders within the entire database. These included: 1) stepwise logistic regression, 2) XGBoost (a decision-tree-based algorithm), and 3) expert variable selection (using likelihood-ratio tests and generalized linear modeling).

My thesis advisor, Dr. Alex Metcalf, ran the stepwise logistic regression, following methods detailed in Metcalf et al. (2019a). He drew a simple random sample consisting of 50% of the easement holders and 50% of the non-easement holders to use as a test dataset. He conducted no further cleaning or tests of assumption as a "least effort" approach to the propensity modelling. He ran a stepwise logistic regression using forward-step Akaike Information Criterion. He validated the model using the remaining data (i.e.,

not the test dataset) with a second logistic regression using variables identified in the final stepwise model to test the prediction that easement holders could be differentiated from non-easement holders using the propensity scores. The goal with this model was to maximize the variance explained by our model, not to identify causal or explanatory variables suggested by any social theory, a key feature of microtargeting (Metcalf et al., 2019a).

A statistical advisor on the project, Dr. John Chandler, explored a "least effort" alternative to logistic regression, using a popular tree-based method, XGBoost (Chen & Guestrin, 2016). XGBoost has enjoyed great success since 2016 as an off-the-shelf approach to data science competitions such as Kaggle (Becker, 2018). XGBoost is an implementation of gradient boosted decision trees, where an ensemble of models is created with each successive model being trained to correct error from earlier models. Dr. Chandler attempted to model a "fully automated approach" to using XGBoost with the following variable selection steps (Table 2):

Table 2 XGBoost Variable Selection Steps

Step	Description	Num. Var. Remaining
Start	All variables in the merged dataset (TargetSmart and Montana Cadastral data combined), except the response and the primary key.	461
Numeric	XG Boost requires numeric variables. To simplify future steps, non-numeric variables were excluded.	378
Missing	Variables with more than 75% of observations were excluded or which were ID variables were excluded.	374
Continuity	We sought to keep variables with continuous values or somewhat-evenly-distributed discrete values. Our process had two steps: • Variables with more than 10 unique values were included. • For variables with fewer than 10 unique values, we required the median representation of values to be at least 10% of the total. This allowed us to exclude discrete variables with a single dominant category.	318
Manual	Four variables were excluded from the analysis either because of known collinearity with other variables or because we did not wish to model at the zip code level	314

The final 314 variables were included in the XGBoost selection set. When fitting, he included all parcels with conservation easements paired to nine, randomly chosen parcels without easements to improve the balance between the cases and non-cases. After experimentation using a training validation set, he selected tuning parameters for the XGBoost model with the learning rate (η) set to 0.1 and a maximum tree depth of 4. He chose 3 for the number of boosting iterations. He used the binary logistic objective function given the binary nature of the response variable. Model performance was estimated against a hold-out test set, though the results show the fitted values for the entire data set.

For the expert variable selection, I hand selected variables from the complete clean dataset (initial n = 447) for their relevance to the behavior of selling or donating a conservation easement (final n = 196). For example, I included variables that the literature or my experience suggested may be at least tangentially related to easement decisions (e.g., acreage, land value, urbanicity or how urban or rural a parcel is), and environmental behaviors (e.g., whether the individual is environmentally minded, whether they have donated to an environmental organization), and excluded variables that seemed entirely unrelated to easement decisions (e.g., store credit card ownership, car ownership, coffee connoisseur, Christian music listeners, cat ownership). I also removed landowners with significant missing values among the variables selected, leaving a total of 106,107 landowners for the final analysis using this approach. Because the number of conservation easements (n = 286) to non-conservation easements (n = 106,393) ratio was so lopsided, I randomly divided the dataset into a test set which included 75 conservation easement holders and 750 non conservation easement holders and a training set which included the remaining conservation easement holders (n = 211) and a randomly pulled 10 times non-conservation easement holders (n = 2110). The purpose of dividing the data into a test-set and training-set in this manner was to estimate the performance of the model as it would later be used to make predictions on data not used to train the model.

I conducted likelihood-ratio tests comparing univariate models to a null model (i.e., a model without predictors) to first remove potential explanatory variables that showed no evidence of predictive power. Using the p-values derived from the likelihood-ratio tests (Appendix F), I sequentially added variables with the most significant p-values into the model to determine if their addition improved the model fit. This was an iterative and subjective process where variables were added and removed by hand as different combinations of variables changed the model fit.

To determine the performance of the model, I generated a Receiver Operating Characteristic (ROC) plot. A ROC curve paired with Area Under the Curve (AUC) tells us how much the model is capable of distinguishing between conditions (i.e., easement holders vs. non-easement holders). The ROC curve is plotted with sensitivity against specificity, meaning the true positive rate (TPR) against the false positive rate (FPR) (Narkhede, 2018).

$$Sensitivity = \frac{True\ Positive}{True\ Positive + False\ Negative}$$

$$Specificity = \frac{True\ Negative}{True\ Negative + False\ Positive}\ ,\ False\ Positive\ Rate = 1 - Specificity$$

A measure of 1 would indicate perfect model performance and a measure of 0.5 would indicate a random forecast (Kuhn et al., 2020). In other words, the higher the AUC, the better the model is at predicting 0s (i.e., non-easement holders) as 0s and 1s (i.e., easement holders) as 1s. In contrast, the closer the AUC to 0.5, the less the model is adding value over random guesses. In other words, for our purposes here, the higher the AUC, the better the model is at distinguishing between landowners with conservation easements and landowners without conservation easements.

Once the final model was evaluated with the steps discussed above, I applied the model to the entire landowner dataset to estimate a propensity score for each landowner. A propensity score is a score given to a unit of observation, in this case a landowner, to attempt to estimate the effect of a treatment, in this case likelihood of participating in a conservation easement.

After completing the three models and assigning a propensity score to every landowner based on each model, I then compared the performance of the models and an "ensemble model"— which was simply an average of the propensity scores generated for each landowner by the three models. To determine which model predicted conservation easements best, I sorted the probabilities from each model individually from highest to lowest, split the sorted probabilities into 100 tiers containing about 1800 parcels each, and calculated the rate of easements by tier (i.e., the rate of actual conservation easements in each probability tier). If the model performed well, parcels with the highest probability would be in the same tier as parcels that actually have conservation easements. First, I plotted a ROC and calculated the AUC for each model (i.e., stepwise logistic regression, XGBoost, expert selection, and ensemble). In a complementary and easier to interpret analysis, I divided each model's probabilities into even deciles (i.e., 10 groups) and tallied the number of actual easements within each decile. Finally, to understand whether the three models were producing similar or divergent probabilities for every given parcel, I plotted a covariate matrix contrasting each model against all others. To show an example of how this data might be visualized we then used ArcGIS to display the spatial distribution of the Stepwise model's probabilities at the parcel level (i.e., polygon level), thus visualizing social receptivity to conservation easements across the state of Montana.

RESULTS

The TargetSmart database contained data on 848,070 Montana residents across 1,400+ variables. The Montana Cadastral contained property information for approximately 450,000 landowners. We excluded about 21% (n = 93,991) of Montana landowners because landowner names were businesses, LLCs, trusts, partnerships, associations, or other types of owners that could not be matched to the commercial dataset which is only available for individuals. We were able to successfully match 51% (n = 180,933) of individual Montana landowners with the TargetSmart commercial database. Due to duplication of information (e.g., several entries for age, gender, address, etc.) and missing values for a substantial

number of landowners, we only included 447 commercial variables in our modelling attempts. To these variables we added all additional land attribute data (e.g., total acreage, land value, farm acres) from the Cadastral. The final database for analysis included 180,933 landowners with 461 variables.

Based on the ROC/AUC analysis, with the stepwise logistic regression model, we were able to successfully differentiate known conservation easement holders and non-holders 89.5% of the time. This model was 1.79 times (79%) better at correctly identifying conservation easement participants than random (Figure 16).

Using the XGBoost model, we were able to differentiate 92.4% of the conservation easement holders from non-holders. In other words, the XGBoost model was 1.85 times (85%) better than a random guess. This gain reflects a more than 3% improvement over the stepwise logistic regression (Figure 16).

The expert variable selection model (i.e., Hand-Tuned) correctly differentiated 93.2% of the easement holders from non-holders. This was approximately 1.86 times (86.4%) better than no model (e.g., randomly guessing), reflecting a slight gain (0.87%) over the XGBoost model (Figure 16).

The ensemble model performed best, correctly differentiating between conservation easement holders and non-conservation holders 93.6% of the time (Figure 16).

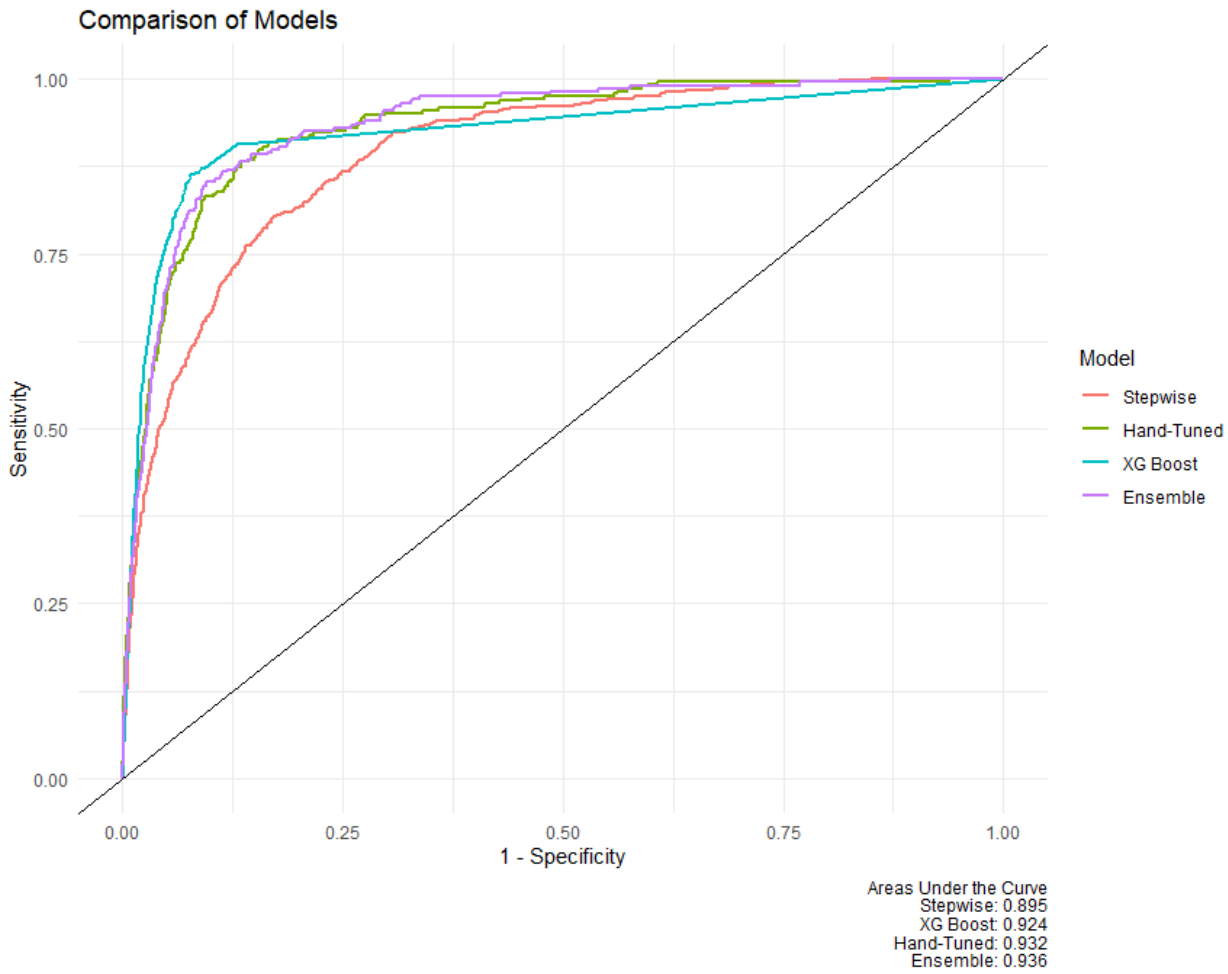

Figure 16 Receiver Operating Characteristics (ROC) curve and Area Under the Curve (AUC) plot for all models.

The actual number of easements within propensity score deciles decreased for all models across most deciles (Figure 17). The stepwise and hand-tuned models showed the steepest decline across deciles, whereas the XGBoost model showed more modest decline (Figure 17).

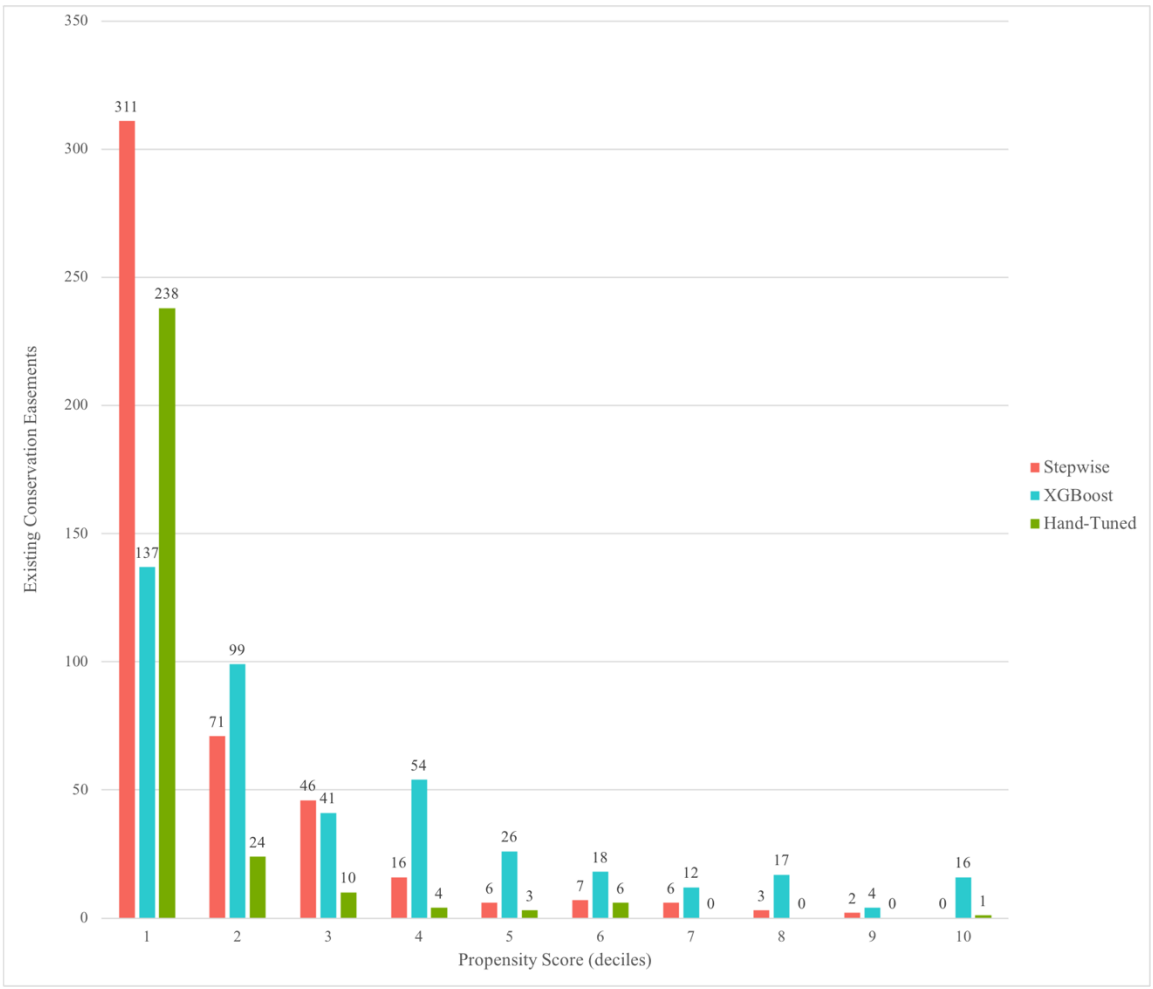

Figure 17 Actual Conservation Easement Count by Decile

The covariance matrix showed generally positive relationships among the probabilities generated by each model for each parcel (Figure 18). Again, the stepwise and hand-tuned models showed the highest degree of similarity to each other, whereas the XGBoost model probabilities followed a grouped output progression, typical of the algorithm.

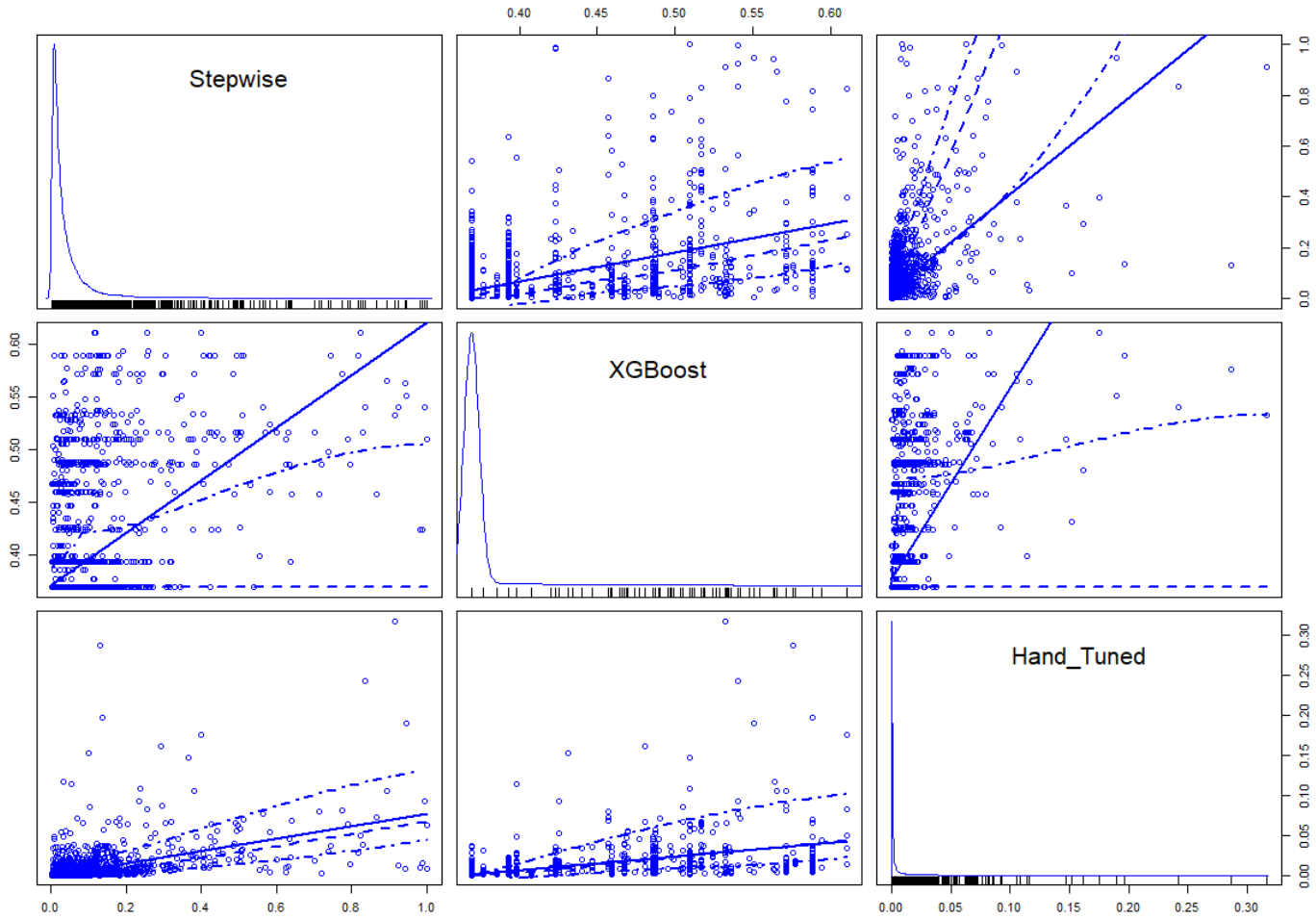

Figure 18 Parcel Level Covariance Across Models

Figure 19 shows the map of Montana with the propensity scores and their given willingness cutoff scores.

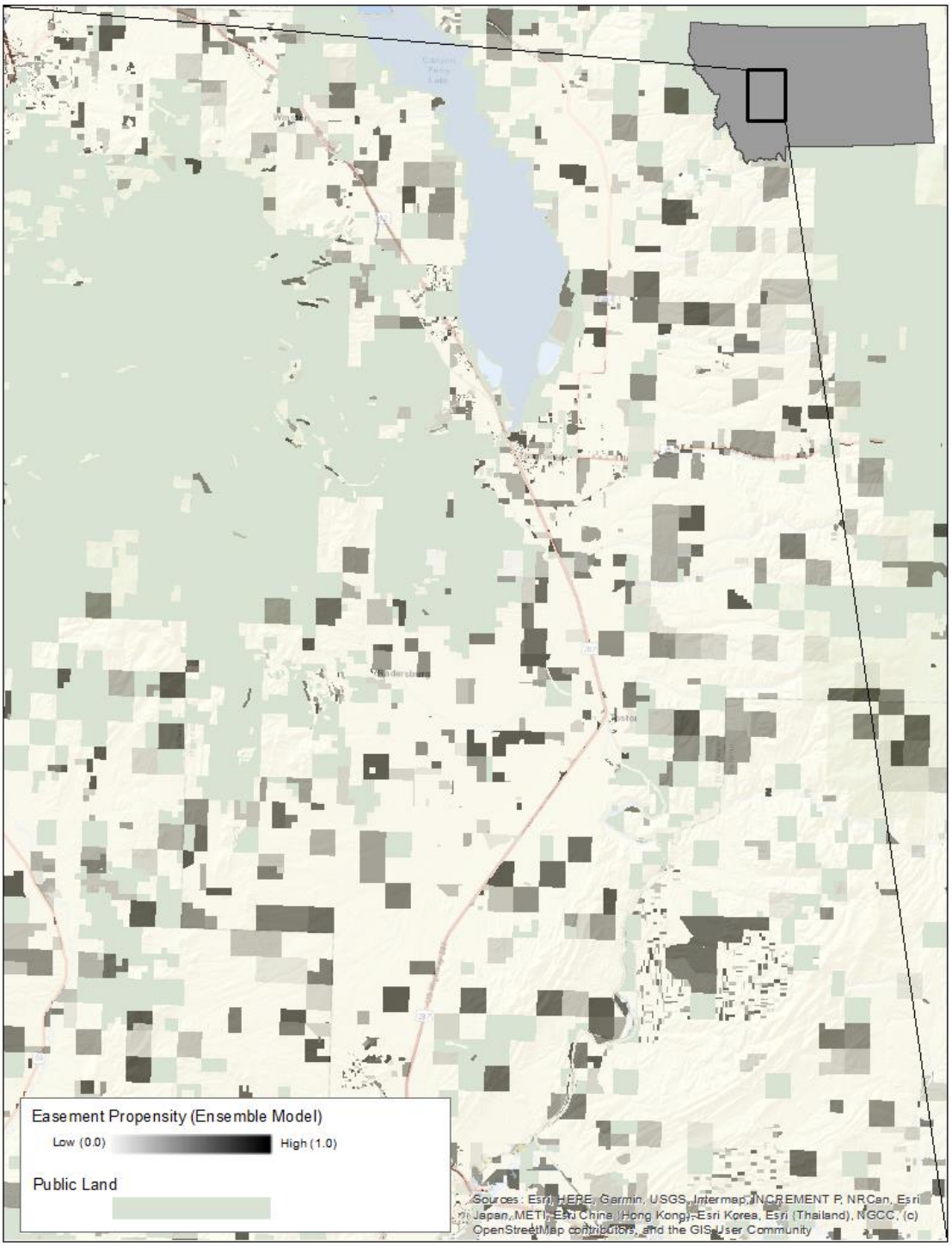

Figure 19 Example propensity score map of Montana using Stepwise Logistic Regression probabilities.

DISCUSSION

Conserving large open land areas is increasingly difficult as urban sprawl and expansion of the Wildland Urban Interface (WUI) continues in the United States. Conservation easements are a key solution to this problem, but prioritizations of where to invest in easement acquisition are mostly based on biophysical landscape attributes that fail to consider social receptivity to easements, especially at fine scales (i.e., the parcel-level). Incorporating social variables into prioritizations has been challenged by data availability and extant analysis approaches. Here, I was able to apply microtargeting techniques using publicly available data paired with commercial data to predict landowner propensity for conservation easements at the parcel-level for an entire, large, US state— Montana. These modeling techniques were able to predict landowner willingness to participate in a conservation easement 89.5–93.6% of the time indicating strong potential for identifying landowners with higher interest in future conservation easements. Land trusts and other conservation organizations can use this approach to better inform their outreach efforts, allocate their resources more efficiently, and have more success achieving their conservation goals, although further advances are possible and worthy of exploration.

From the ROC/AUC analysis, the models performed unevenly, with the stepwise logistic regression being least accurate, and the hand-tuned model the most accurate of the three individual models, which was only slightly better than the XGBoost model (Figure 16). The ensemble model performed best, most likely because although missing data issues occurred in each model, they occurred in different places such that averaging model outputs evened out these errors to some degree. The models were 1.79–1.86 times better at identifying landowners interested in easements than a model with no covariates. Meaning, if there was a choice between two parcels of equal conservation value and information about their owners was equally available, the model can nearly double the chances of successfully identifying which landowner would be more likely to engage in a conservation easement. From another perspective, the model could reduce recruitment costs by half while leaving unaffected easement success; or double the number of recruited landowners while leaving costs unchanged.

The decile analysis allows us to more tangibly see how the models performed at predicting conservation easements (e.g., by assigning a higher probability) and count how many actual conservation easements were in each decile (Figure 17). Though this model shows that the Stepwise logistic regression outperformed both the XGBoost and Hand-Tuned models, this is more a function of the grouping forced by the deciles, whereas the ROC/AUC analysis more precisely measures model performance.

Figure 18 shows that the models performed relatively similarly at the parcel level (i.e., the models each predicated relatively similar probabilities for each parcel). In other words, there was little evidence that different models were assigning wildly different easement probability scores to the same landowner. However, the Stepwise and Hand-Tuned probabilities were more similar to each other than the XGBoost model, most likely the result of the probability assigning method implicit in the XGBoost algorithm, which assigns groups of landowners identical probabilities in batches, rather than calculating a unique score for each individual landowner.

The microtargeting modeling approach has several advantages over previous efforts to incorporate social values into prioritization plans. A primary advantage is that this analysis is conducted at the individual parcel-level and is therefore specific to each landowner and parcel. Importantly, however, this approach does not require a survey or other contact with individual landowners to collect psychometric or behavioral data, thus substantially reducing costs, including time, expertise, and data collection. In part because microtargeting does not require primary data collection, this approach allows for estimation of conservation easement propensity over a wide extent— tens of thousands of landowners over hundreds of thousands of square miles in this example, rather than just a few hundred landowners typically included in survey samples. Despite being finer resolution and available at a wider extent than previous efforts, this approach is exceedingly affordable because it relies on free public landownership data, affordable and accessible consumer data (e.g., our dataset cost $2,500), and relatively simple analysis techniques, especially the best performing individual model (i.e., the hand-tuned logistic regression).

With spatially explicit parcel data, the microtargeting approach enables the joint analysis of social data and predictions to biophysical resources of the user's choosing over large landscapes. Through the attribute information associated with most Cadastral data, researchers and practitioners can identify the property owner, and, via consumer data, myriad characteristics about them which can be related to different conservation behaviors. Through the georeferenced, spatial information that is core to all Cadastral data, users can intersect a wide array of conservation value datasets, including any of the many biophysical prioritization datasets increasingly available (e.g., habitat, access, agricultural land, restoration). Together, the social and biophysical data can be analyzed in sequence (e.g., first conservation value, then social receptivity) or in unison (e.g., places where conservation value and social receptivity are optimized) to inform countless different prioritizations, informed by both human and ecological dimensions.

The examples of joint, social and biophysical prioritizations enabled by a microtargeting approach are seemingly endless. One example in Montana are the ongoing efforts to build landscape connectivity between disparate populations of grizzly bears (*Ursus arctos horribilis*). Extant prioritizations of corridors have only considered biophysical conditions but could benefit from joint analysis with social receptivity data on landowners' willingness to take conservation action (e.g., sell or donate a conservation easement). In Chapter 3, I detail one way to perform this type of joint analysis which reveals which of three possible corridors has the least social resistance to conservation easements. Other paired conservation value possibilities include winter ranges for wildlife (e.g., rocky mountain elk habitat connectivity), climate resilience (i.e., land that will sustain native biodiversity even as the changing climate alters current distribution patterns), and soil conservation (i.e., farmland soils that qualify for NRCS funding under the Agricultural Land Easement program). Toward slightly different ends, the microtargeting easement propensity model could inform a least cost pathway analysis to identify which of the many private parcels currently blocking public access to currently landlocked parcels of public land

are owned by people most receptive to conservation easements (Theodore Roosevelt Conservation Partnership & OnXMaps, 2018).

My model validation tests demonstrated that a microtargeting approach to prioritizing easement investments could save considerable resources for land trusts, public agencies, and other easement-seeking entities. Specifically, I was able to correctly estimate the presence of an easement 1.8 times better than a random guess. Although we know conservation groups are not randomly approaching landowners, if even a fraction of this advantage remains over existing outreach lists, conservation groups could realize substantial savings by choosing more wisely those landowners with whom they approach and build relationships with toward conservation easements. Additionally, many land trusts do not know where to start contacting landowners because the landscape is so large, the number of owners so many, and the chances of success so low. To solve this problem, the microtargeting approach can order the list of landowner prospects based on easement propensity, giving these organizations a direction to pursue that is likely to conserve important resources and, perhaps most importantly, more likely to succeed by securing an easement.

Although the results presented here are extremely promising, more work is needed to refine and expand the microtargeting technique to estimating landowners' propensity toward conservation easements. One major limitation here is that the consumer data we purchased did not match to any landowners who were not individuals, thus excluding Limited Liability Companies (LLCs), trusts, or others. Some of these types of ownership represent several individuals, while others may only represent one. Future work could pursue data, for example through the Secretary of State's offices, to better link individuals (or one of many individuals) associated with these ownership types to their consumer data, thus dramatically expanding the number of parcels included in the analysis. For example, businesses, LLCs, trusts, partnerships, associations, or other types of owners made up approximately 21% percent of all Montana landowners, so capturing even a small percentage of this population segment would be valuable.

Computing power was also a limiting factor. We did not pursue analyses which would have required investments in computing power, but even the resources required by our methods may not be readily available to many conservation organizations. Data availability, cleanliness, and data vendors could also be improved. The availability of consumer data is growing rapidly, but so too is the uncertainty of its quality. Much of the data I received required cleaning (i.e., detecting and removing corrupt or inaccurate records from a database), which is arduous and perhaps unfamiliar to conservation organization staff. Future work could evaluate similar modeling techniques using a different, or several different, commercial datasets to understand the advantages and disadvantages of each.

As researchers and practitioners weigh the costs and benefits of adopting microtargeting for informing their conservation investments, it will be important to build systems that incorporate continuous changes in landownership, which can change daily. Designing an automated process to update propensity models with landownership data and new commercial data would be ideal, however that could be costly and require investments from foundations or other supporters.

Although our model validation tests suggest that microtargeting can successfully predict landowners' propensity for conservation easements, ground truthing will be important. The models suggest that by applying this method, predicting landowner propensity increases by 1.79–1.86 times (79–86%) versus not applying the model at all. To best determine if this lift holds true for conservation organizations, it would be ideal to set up a controlled experiment where land trusts contacted landowners they would normally contact as well as landowners identified by our model and tracked the relative rates of success and resources required to achieve that success. Conservation easements typically take about 3 years to complete from initial communication to closing paperwork with the landowners. These data could help us understand definitively whether microtargeting improved that timeline, reduced necessary resources in other ways, or simply led to more success given similar resource investments.

Microtargeting also raises unique ethical considerations that we encourage conservation organizations to proactively consider. Conservation easements are often built on relationships of trust between landowners and land trust employees. Does a microtargeting approach undermine this trust? How might conservationists describe this work and the data it required? The world we live in is full of companies, politicians, and others who are constantly mining our personal data to target us for consumer ads, political persuasion, or other outcomes. Organizations should consider the pros and cons of adopting similar techniques for conservation outcomes. Do the altruistic ends outweigh the discomfort we have with such data? Are there best practices conservationists can adopt to protect landowner privacy while using these data to realize the benefits offered by this powerful approach? Does the fact that these data already exist, are public, and are used almost ubiquitously by others with less-wholesome intentions make it more acceptable for conservationists to join the bandwagon? These are real and important questions conservationists must answer before adopting a microtargeting approach.

The variables that were significant and used to build each model were different in all three models. As explained in the book *Big Data*, when using analytics approaches to make predictions, we do not need to search for causality or explanation; instead, the patterns and correlations in the data offer novel and invaluable insights helpful for making predictions. Correlations may not tell us why something is happening, but they inform us that something is happening or likely to in the future. In many situations, such as predicting conservation easement propensity, this is good enough (Mayer-Schönberger & Cukier, 2014).

This approach challenges traditional conservation social science approaches to understanding behavior. Our aim is to predict the likelihood of a future event; our interest in 'why' is limited to those theories and data which can help in that prediction. Prediction is where the value in this approach lies. Prediction informs us that something is likely to happen, which is what we desire to know. The why of this prediction is important, but cannot help anticipate the likelihood of future when data are unavailable or not widely available. Where data are available for theory-informed variables, combining them with all

other data that prove useful for predictions (regardless of their logical or theoretical relationship to the behavior of interest) seems prudent.

Big data approaches to understanding human behavior, such as microtargeting, often succumb to a few common pitfalls. In her book *Weapons of Math Destruction,* Cathy O'Neil (2016) details common characteristics of malicious models as being opaque, scalable, and damaging. Often, these predictive models are considered proprietary, so their makeup is hidden in a black box. They can affect large numbers of people, part of the advantage of using these models is applying their outcomes to a large body of people, however with this comes the possibility of getting the predictions wrong for some of them. Lastly, many of the models O'Neil outlines can be extremely damaging to people by unknowingly (or knowingly) encoding racism or other biases into the models or allowing companies to advertise to a targeted group of people who may be vulnerable for one reason or another. This is extremely harmful if you use these algorithms to make decisions about people's livelihoods. Our approach to microtargeting naturally avoids some of these but must be careful to avoid others.

As mentioned previously, the models presented here were built on one dataset and used three different methods to test their prediction effectiveness. We are open to sharing the code so that others can tweak it and make it better. This transparency will be critical for helping to ensure microtargeting models avoid some of the common pitfalls of big data approaches. With respect to scale, we limited our model to one US state and encourage future modelers to replicate our methods (or improve them) using state-specific conservation easement and consumer data. Extending our predictive model to other states would be inappropriate. Future modelers should also explore the tradeoffs between model extent and accuracy. With respect to doing damage, conservation actions are not someone's health, job, or finances.

Still, the potential damaging outcomes of this model may include land trusts not contacting landowners who scored low but in fact would be likely to place a conservation easement on their land (i.e., Type II model error), or mistakenly investing resources in landowners who are actually not interested in

easements (i.e., Type I model error). Although likely not as serious as health outcomes, these are real consequences for conservation organizations whose budgets are already limited, so care should be taken to understand model efficacy and utility before investments are committed. Despite the debate and discussion regarding prediction vs. explanation, the best performing model here was a marriage of these two approaches — variables hand selected based on known and hypothesized causality, and their added significance to the null model (i.e., their added value to the predictive model.)

CONCLUSION

Microtargeting is a promising tool for adding social considerations to biophysical prioritizations for conservation investments. Land trusts can use this method to inform which landowners they approach for land acquisition; conservation researchers can use this social receptivity map to answer important research questions; conservation non-profits could use it to determine where and who their most impactful donors might be; conservationists and restorationists can use this to determine areas with the most need and least willingness to conserve and brainstorm alternative conservation and restoration methods. There are real questions about the mechanics and ethics of big data's applicability in conservation, but the power afforded by these approaches could transform conservation prioritization and organizational efforts to achieve conservation outcomes.

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Chapter 3

Grizzly Bear Conservation Corridors and Parcel Level Social Receptivity: *An application of data analytics to wildlife conservation*

INTRODUCTION

Western Montana's landscape between the Greater Yellowstone Ecosystem (GYE) and Northern Continental Divide Ecosystem (NCDE) is home of two isolated grizzly bear (*Ursus arctos horribilis*) populations (Figure 20) (U.S. Fish & Wildlife Service, 2020). Grizzly bear populations in the GYE and the NCDE have drastically increased in quantity and range since the 1970's (USFWS, 2020). Genetic connectivity between these isolated populations is a long-term management goal (USFWS, 2020). The grizzly bear is listed as threatened in the contiguous United States and endangered in parts of Canada (USFWS, 2020) and is an extremely important species for biodiversity and conservation as it is considered an umbrella species. Umbrella species are those with either large habitat needs or other necessities whose conservation results in many other species being conserved at the ecosystem or landscape level (Hassan, Scholes, & Ash, 2005).

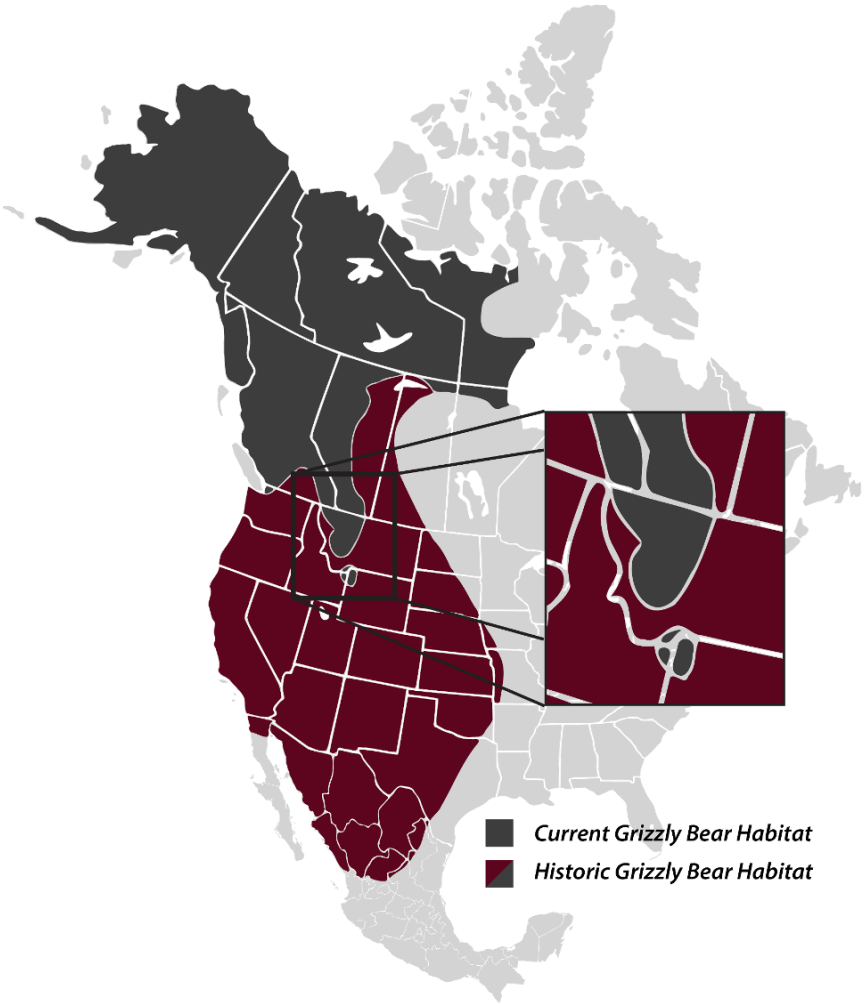

Figure 20 Current and historic grizzly bear range (Range data from Feldhamer, Thompson, Chapman, 2003).

The landscape surrounding these two ecosystems, GYE and NCDE, is a mosaic of private and public land ownership, resulting in fragmented habitats, biodiversity loss, and inconsistent land management. Conservationists have been working to reverse these trends, including promoting endangered grizzly bear populations, by exploring the concept of conservation corridors between intact habitats. Conservation corridors are contiguous areas of protected land that connect wildlife populations which help to reduce the risk of extinction. One of the tools used to achieve these conservation corridors has been conservation easements.

A conservation easement is a negotiated, legally binding agreement between the individual(s) who own property and a second-party organization such as a state or federal agency, or a nongovernmental organization such as a land trust (Farmer et al., 2011). This conservation tool is appealing to conservationists because it is often more attainable than large scale policy creation or change, as well as less costly than complete acquisition (i.e., purchasing the land outright), making them an ideal tool for corridor construction (Farmer et al. 2011).

Given the ever-limiting resources and constraints in conservation, realistic prioritizations of land for corridor protection must be identified (Lombard et al. 2010; Arponen 2012). There have been many efforts to prioritize biodiversity conservation in the form of conservation corridors, however, these prioritization efforts typically do not include social aspects, especially not at fine, parcel-level, scales (Pouzols & Moilanen, 2014; Proctor et al., 2015; Snäll, Lehtomäki, Arponen, Elith, & Moilanen, 2016; Dilkina et al., 2017;). Prioritization becomes especially important when considering protecting an entire wildlife corridor or region that includes several private parcels (Schuster and Arcese 2015).

Organizations such as the Yukon to Yellowstone Conservation Initiative and Vital Ground Land Trust have long prioritized private and public lands for corridor protections. In a study by Peck et al. (2017), biologists identified three estimations of movement for potential migration of male grizzly bears to better understand where connections between the NCDE and GYE populations could be made (Figure 21). The three corridors (West, Central, East) generally ran along mountain ranges and several of Montana's National Forests, however, they also intersected large population centers (Peck et al., 2017). This presents a unique challenge as there have now been ecological prioritizations identified, however, parcel level information about landowners' interest in conservation easements is unknown.

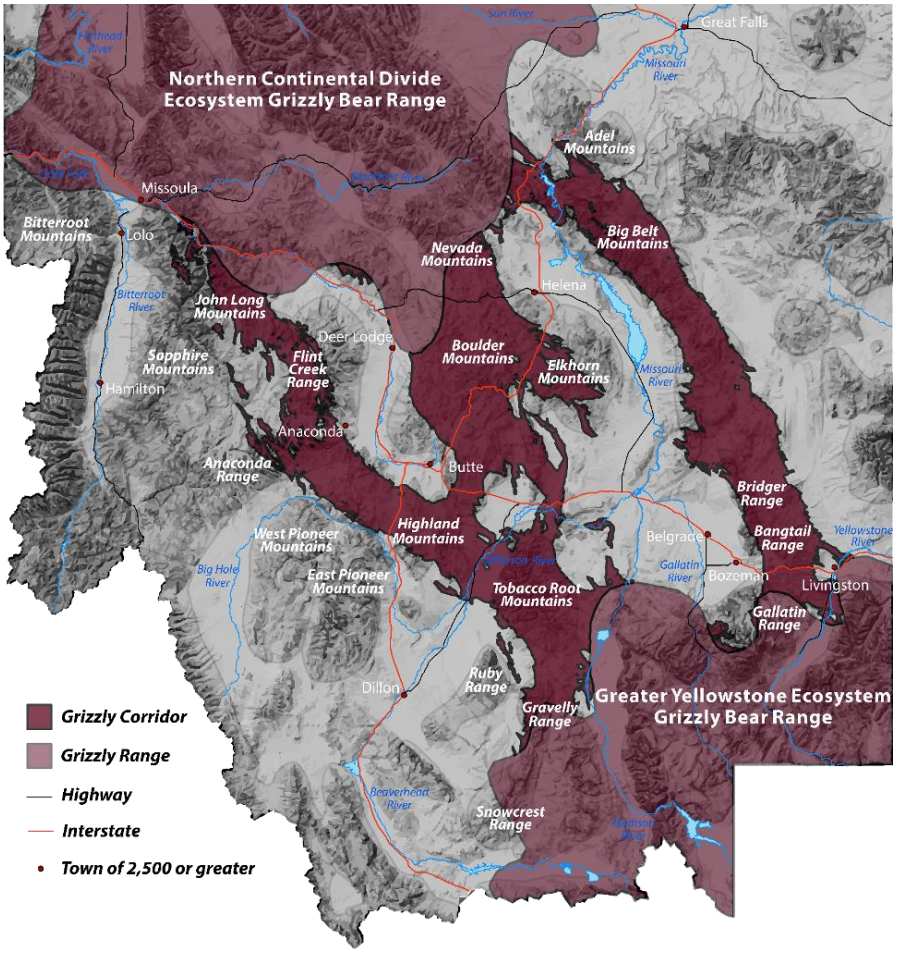

Figure 21 Current range and migration movement corridors of grizzly bears from Peck et al. study in relation to western Montana's largest population centers and mountain ranges (Offer, 2020).

In this chapter, I explore how the model I developed to predict landowner propensity to participate in a conservation easement might improve grizzly bear corridor prioritization efforts by adding social considerations to existing biophysical models. To do so, I will apply landowner propensity scores developed in Chapter 2 to characterize the social receptivity to easements across three proposed grizzly bear corridor options.

METHODS

To demonstrate how easement propensity data can refine extant biophysical prioritizations, I began with three potential grizzly bear migration pathways (i.e., "corridors") between the NCDE and the GYE

developed by Peck et al. (2017). There, the authors used step-selection functions to generate layers of ecological, physical, and anthropogenic landscape features associated with non-stationary GPS locations of 124 male grizzly bears (Peck et al., 2017). Then, using a randomized shortest path algorithm, they identified paths for three levels of random deviation from the least-cost path (Peck et al., 2017).

Here, I used the landowner propensity to conservation easement scores I developed in Chapter 2 to evaluate the three potential corridors (West, Central, East) identified in Peck et al. (2017). The landowner willingness model was developed using publicly available land information from the Montana Cadastral along with commercial data purchased from TargetSmart, which included several consumer behavior data points for landowners in Montana (TargetSmart, 2019; Base Map Service Center Montana State Library, 2020). These data were combined and run through several modeling techniques— stepwise logistic regression, machine learning, and hand-selected variable model performance— to determine model effectiveness on predicting Montana's landowner's willingness to participate in a conservation easement. Each of the model's assigned a propensity score (between 0 and 1) to each landowner in the database. These scores allow us to determine, at a parcel-level, landowner's receptivity to conservation easements. Chapter 2 of this thesis explains this process in detail.

With the help of my advisor, I tabularly joined the Cadastral dataset to the landowner propensity scores from the stepwise logistic regression model (i.e., propensity score available for every parcel polygon in Montana) and then spatially joined this dataset to the three proposed conservation corridors (West, Central, East). To understand "resistance to easements" rather than propensity, I calculated a resistance score equal to [1 - propensity score] for each parcel, where the higher the value the greater the effort estimated to secure an easement. Finally, I summarized each corridor based on the number of private parcels within each, total acres of private land and public land, and the sum total of resistance scores.

RESULTS

The three corridors differed with respect to total acreage, public and private acreage proportions, and sum total of resistance scores (Table 3). The West corridor had the lowest percent of private land (28%) and the highest percent of public land (72%). The East corridor had the highest percent of private land (65%) and the lowest percent of public land (35%). The Central corridor was in the middle of the other two corridors with 36% private and 64% public land within the corridor.

Table 3 Summary of Corridors and Resistance

CORRIDOR	PRIVATE ACRES	PERCENT PRIVATE	PUBLIC ACRES	PERCENT PUBLIC	TOTAL ACRES	TOTAL RESISTANCE
WEST	490,359	28%	1,269,617	72%	1,759,976	5,913.31
CENTRAL	611,304	36%	1,098,697	64%	1,710,001	6,913.16
EAST	844,047	65%	461,799	35%	1,305,846	3,801.71

The corridors also differed with respect to the sum total of "resistance" scores and overall size (Table X). The Central corridor had the largest sum cost, and the second largest total acres. The West corridor had the second largest sum cost and the largest total acres. The East corridor had the smallest sum cost as well as the smallest total acres. Overall, the East corridor had the least amount of public land (35%), but the lowest total resistance on private land (3,801.71), primarily due to the relatively small number of large acreage private parcels there. The West and Central corridors were both majority public land (72% and 64% respectively), however, they had one third more to nearly twice the resistance than the East corridor across the remaining private land (5,913.31 and 6,913.16, respectively).

DISCUSSION

Adding social receptivity data to ecological prioritization can help better prioritize conservation corridor options. With the added value from the social receptivity at a parcel-level, conservationists can better determine priorities between parcels that may be ecologically identical, but not socially equal. Applying a

layer of social resistance (or lack thereof) will help land managers with their conservation goals, in this case, grizzly bear population connectivity and migration corridor prioritization in Montana.

The differences among the corridors are telling. Knowing that corridors with more public land may be the best least cost pathway (due to public land already having strong protections due to federal regulations) is one way to interpret the corridors. However, based on my analysis here, conservationists may want to focus more on those corridors with landowners who have the least resistance to placing a conservation easement on their land. For example, the East corridor may have the smallest proportion of public land of the three corridors (35%), but it has the lowest total resistance score (3,801.71) across the private land, and the fewest number of private parcels (n = 3,969) (Table 3). Thus, although the proportion of private land is substantial in this corridor (65%), the private landowners there are more likely to place a conservation easement on their land compared to the West and Central corridors.

Using social data in this manner is complex; deciding how to use this information to inform decisions should be a collaborative process with outcomes likely to differ according to context and decision makers' preferences. Here we simply summed the "resistance" scores for all private parcels within each corridor. Our rationale was based on the (likely false) assumption that resistance score is a complete measure of the cost of acquiring an easement. Based on this logic, for example, if corridor A had ten parcels and they're all scored .04 resistance, but corridor B had two parcels, each with .70 resistance, we would find resistance lowest across those 10 parcels; however, this may not necessarily be true. My current approach has not accounted for any fixed costs associated with each easement that might change the calculus. More work is needed to take the propensity model and combine it with other data such as easement costs to best estimate resistance.

Although challenges remain toward refining estimates of social resistance, the propensity model enables this creative work to begin and the resistance comparison here demonstrates the value of such efforts. Considering the social and biophysical together will likely force conservationists to wrestle with tradeoffs

between areas of high ecological value and strong social resistance and areas with greater social receptivity, yet lower conservation value. For example, Peck et al. (2017) suggests there is more grizzly bear movement in the West corridor due to large, contiguous landscapes with limited anthropogenic influence. If the social analysis (once refined) shows that landowner resistance is far lower in another corridor, where should conservationists invest? While social data will not answer these questions completely, they will help ground conservation investment decisions and choices in the social as well as biophysical realities of the landscape, thus increasing the likelihood of conservation success.

Regardless of the choices conservationists ultimately make, these types of social data allow wildlife and land managers to think creatively about how to achieve conservation goals given biophysical and social constraints and opportunities. Further, these data can help improve final decisions by providing information regarding the resources required to build connections with landowners. Pairing ecological prioritization models with social receptivity models gives a holistic view of conservation values and social values. This same methodology can be applied to several different conservation values— climate resilience, farmland soils, elk migration corridors or winter ranges, landlocked public land. Here, I hope to have demonstrated how this is possible, despite not having a perfect solution for informing the challenge of grizzly bear corridor conservation.

There are several ways to improve the pairing of social receptivity to ecological prioritizations. For instance, land ownership changes frequently, therefore constant updates to propensity models would ensure social receptivity of the landowner in question is known and not out of date. The commuting power and knowledge needed to build these predictive models is also something that may not be readily available to many conservation organizations, so investments may be required. Additionally, the availability of commercial data is always expanding; models built on different databases may yield different results or may not. Further exploration on different database sources for building these models is needed.

CONCLUSION

In conclusion, modeling social receptivity alongside ecological prioritization provides a novel and compelling way to incorporate parcel-level social data into spatial prioritizations like conservation corridors. This technique allows fine-scale information from multiple stakeholders to be entered into the equation of conservation values and constraints. Incorporating social data into conservation prioritizations allows conservationists to identify areas where resources can and should be focused as well as areas with high social resistance that will require more creative solutions for conservation success.

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APPENDICIES

APPENDIX A: Glossary

Conservation Marketing is the ethical application of marketing strategies, concepts, and techniques to influence attitudes, perceptions, and behaviors of individuals, and ultimately societies, with the objective of advancing conservation goals (Wright et al. 2015).

Delivery tactics are the strategic actions that direct the promotion of a product or service to influence specific marketing goals (CoSchedule, 2020).

Marketing is the activity, set of institutions and processes for creating, communicating, delivering and exchanging offerings that have value for customers, clients, partners, and society at large (MASB 2020).

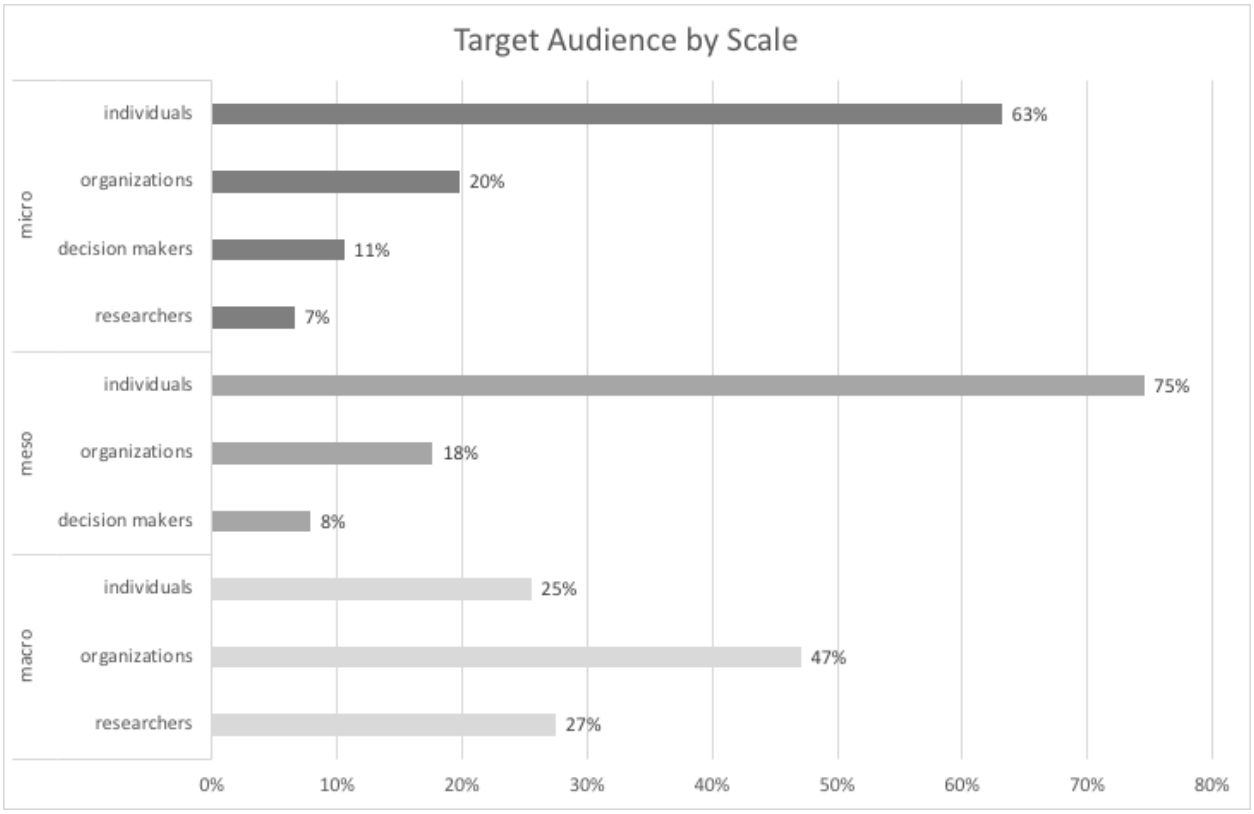
Messaging is a statement of the customer benefit and the specific product performance characteristic that delivers that benefit (MASB 2020).

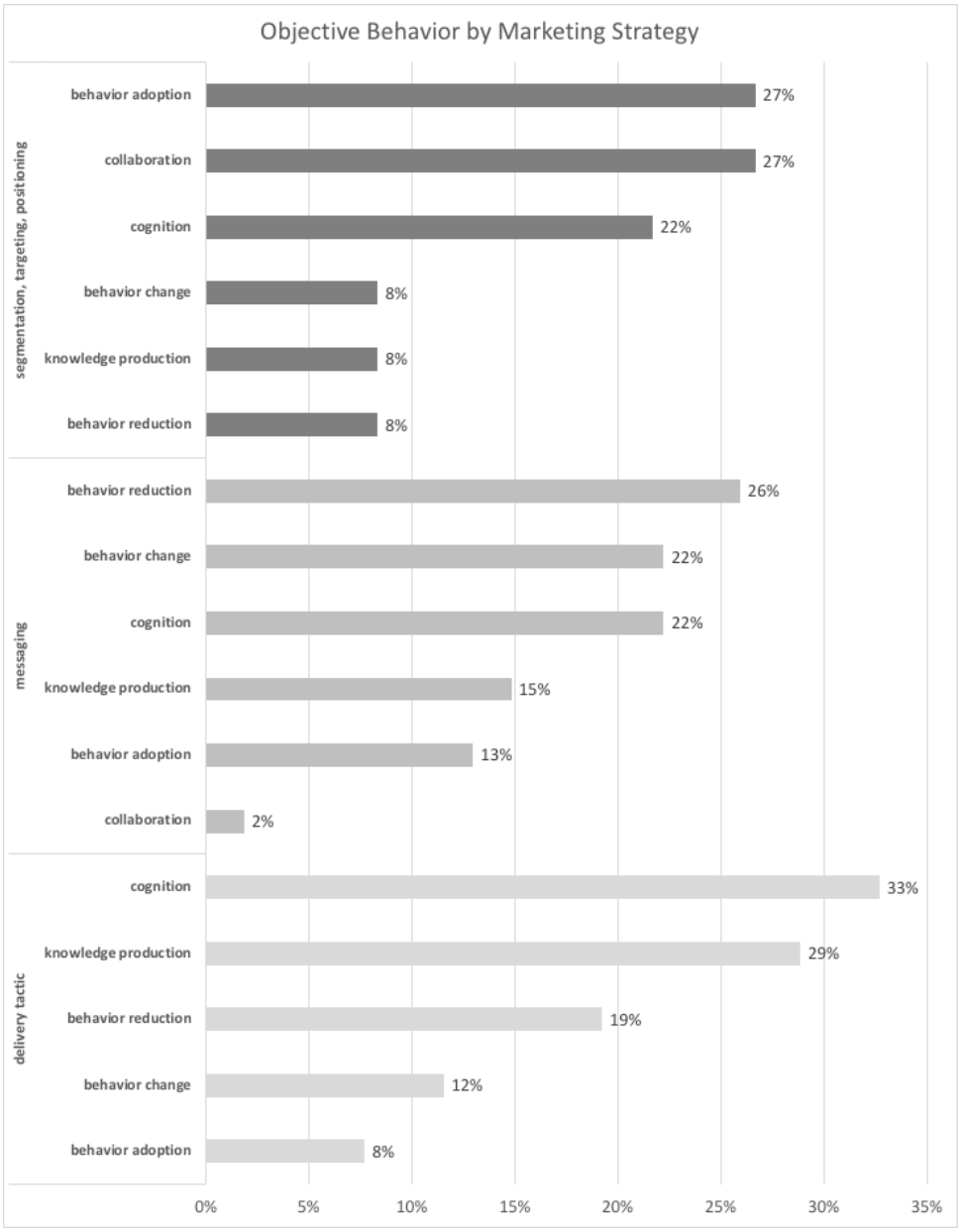
Positioning is where your competitive advantages, products or services that are better or more inexpensive than competitors', are identified and positioned so that the desired behavior is at the consumers' front of mind. (MASB 2020)

Segmentation refers to aggregating prospective buyers into groups or segments with common needs and who respond similarly to a marketing action (MASB 2020).

Targeting is a particular portion of the total population which is identified (i.e., targeted) by the marketer or retailer to be the most likely to purchase its products or services (MASB 2020).

APPENDIX B: Additional Result Figures – Chapter 1




Objective Behavior by Marketing Strategy
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collaboration
27%
cognition
22%
behavior change
8%
knowledge production
8%
behavior reduction
8%
messaging
behavior reduction
26%
behavior change
22%
cognition
22%
knowledge production
15%
behavior adoption
13%
collaboration
2%
delivery tactic
cognition
33%
knowledge production
29%
behavior reduction
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behavior change
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behavior adoption
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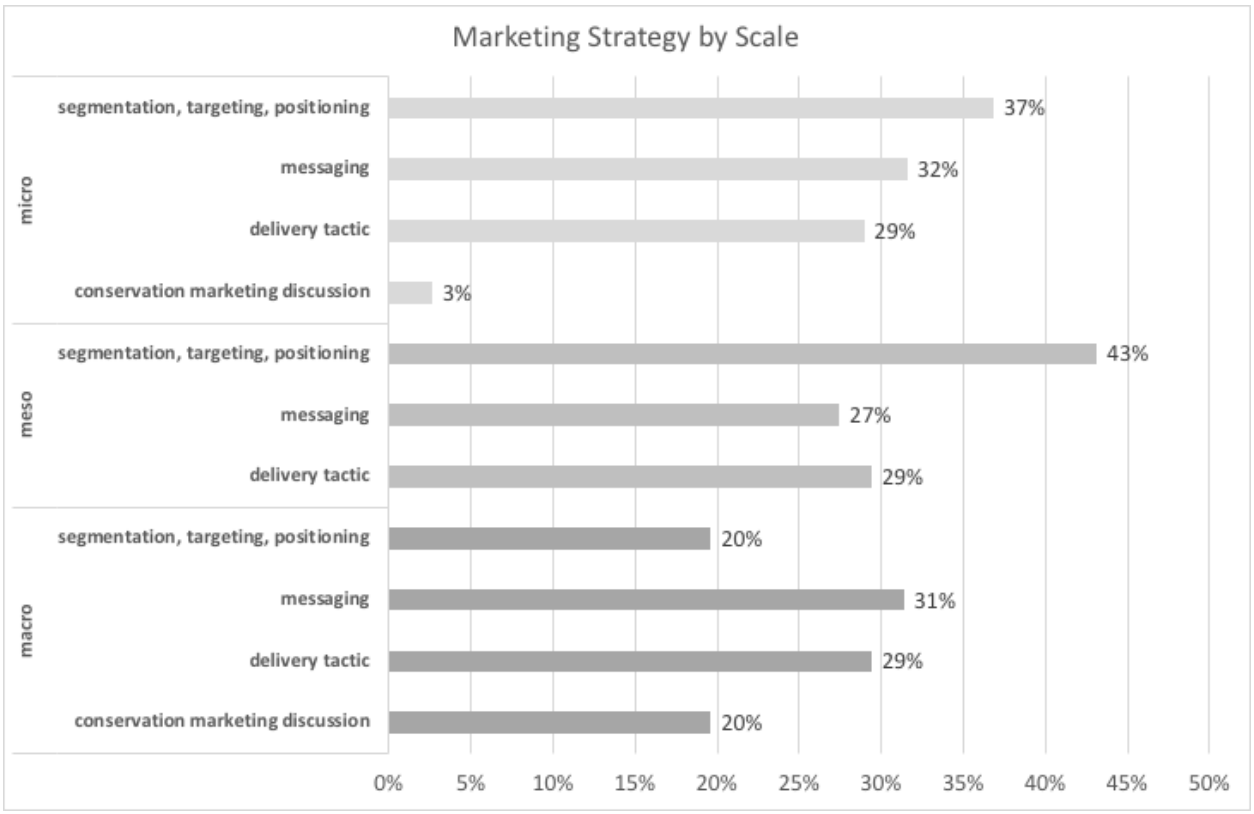
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32%
delivery tactic
29%
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meso
segmentation, targeting, positioning
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messaging
27%
delivery tactic
29%
macro
segmentation, targeting, positioning
20%
messaging
31%
delivery tactic
29%
conservation marketing discussion
20%
0%
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40%
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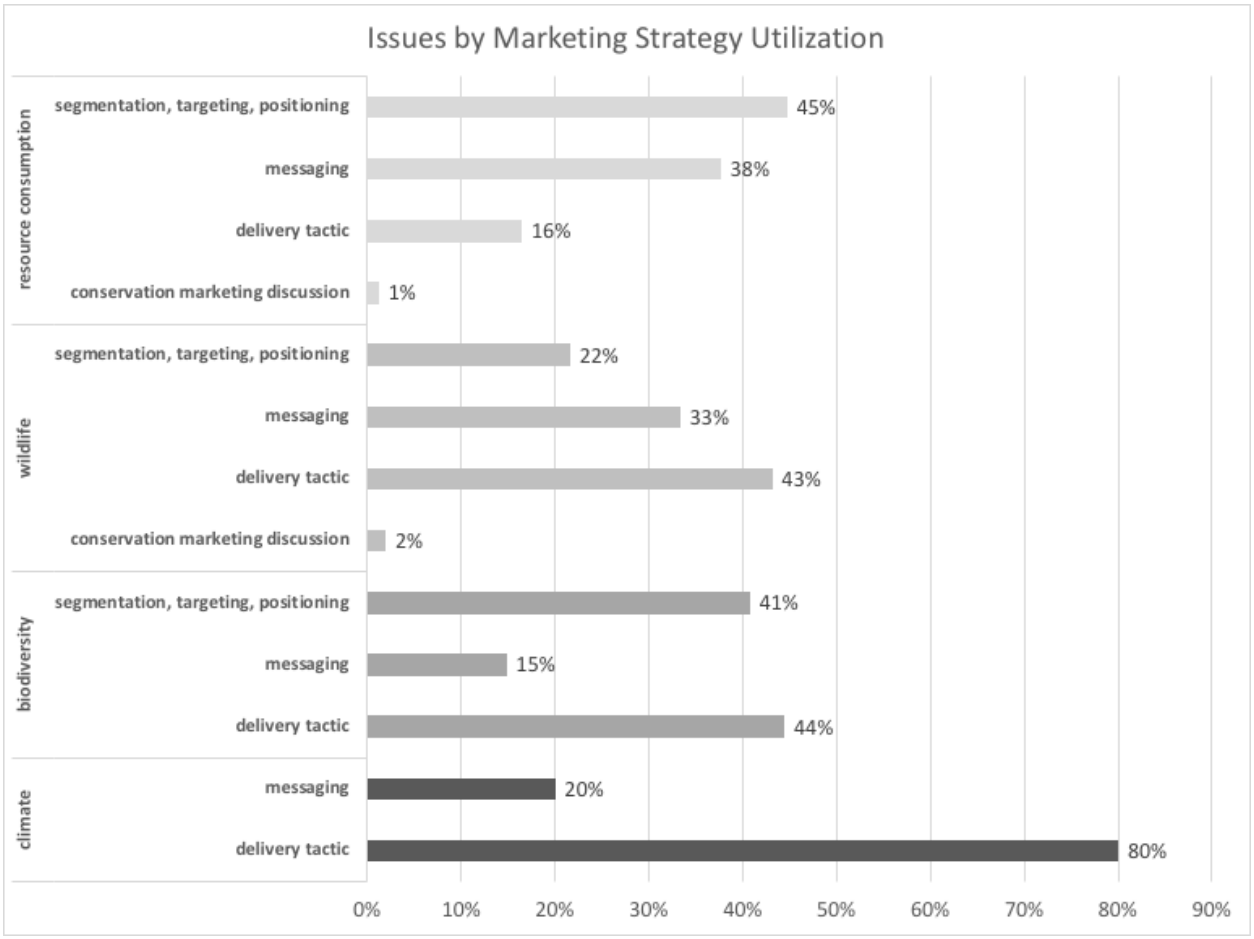
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22%
messaging
33%
delivery tactic
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conservation marketing discussion
2%
biodiversity
segmentation, targeting, positioning
41%
messaging
15%
delivery tactic
44%
climate
messaging
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delivery tactic
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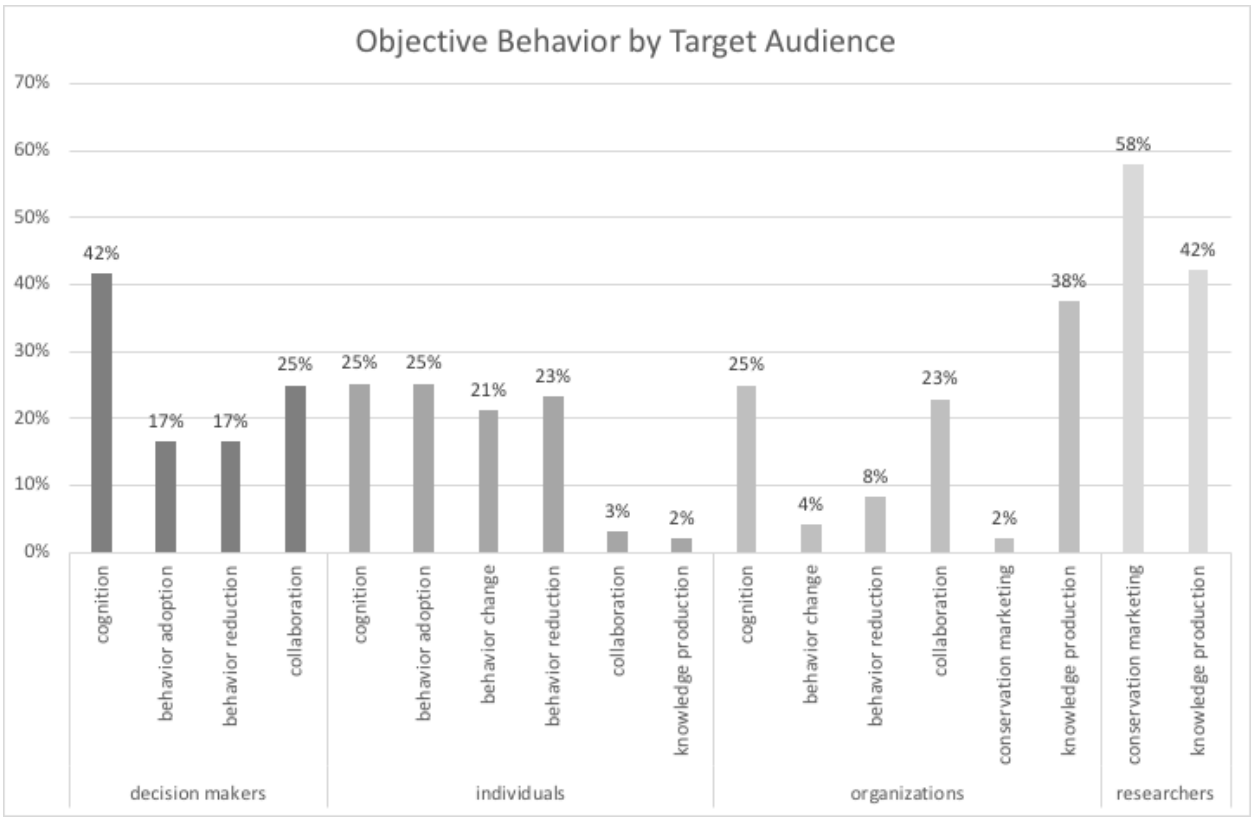
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58%
42%
cognition
behavior adoption
behavior reduction
collaboration
cognition
behavior adoption
behavior change
behavior reduction
collaboration
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cognition
behavior change
behavior reduction
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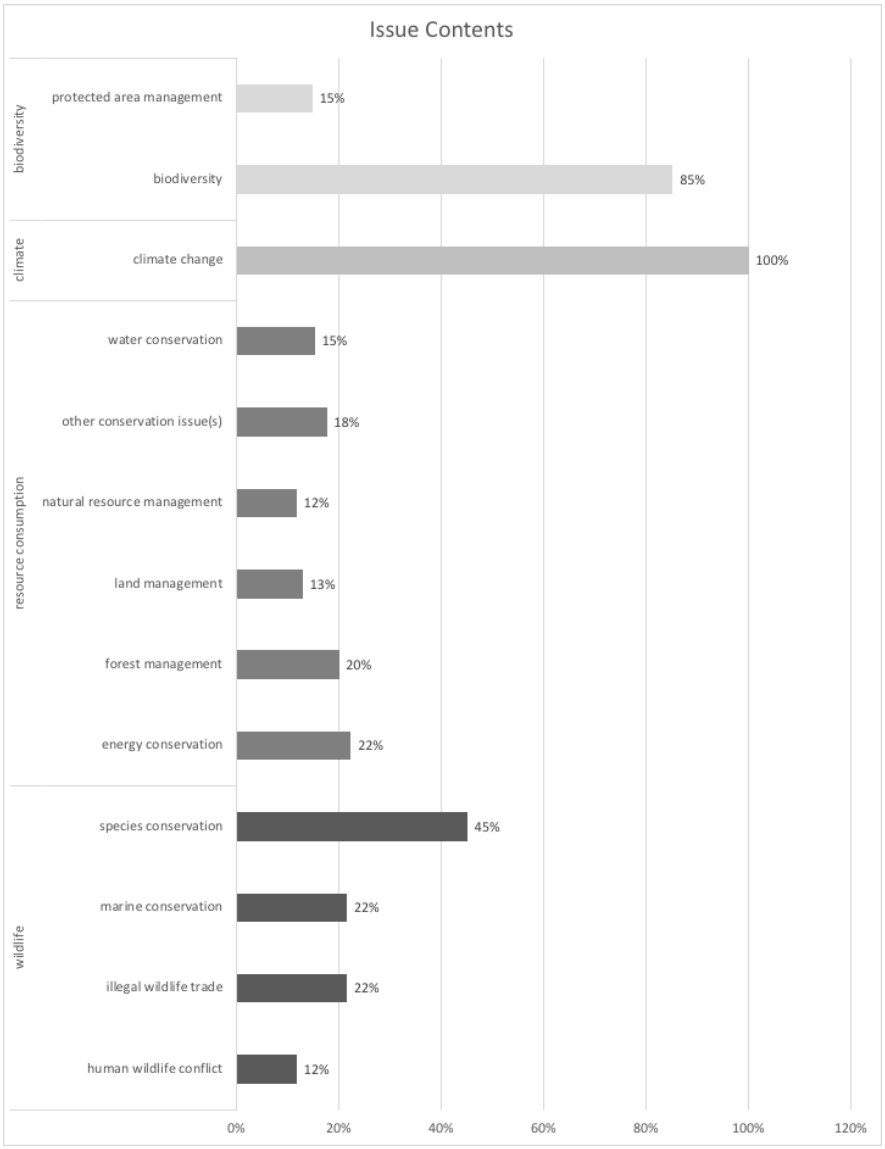
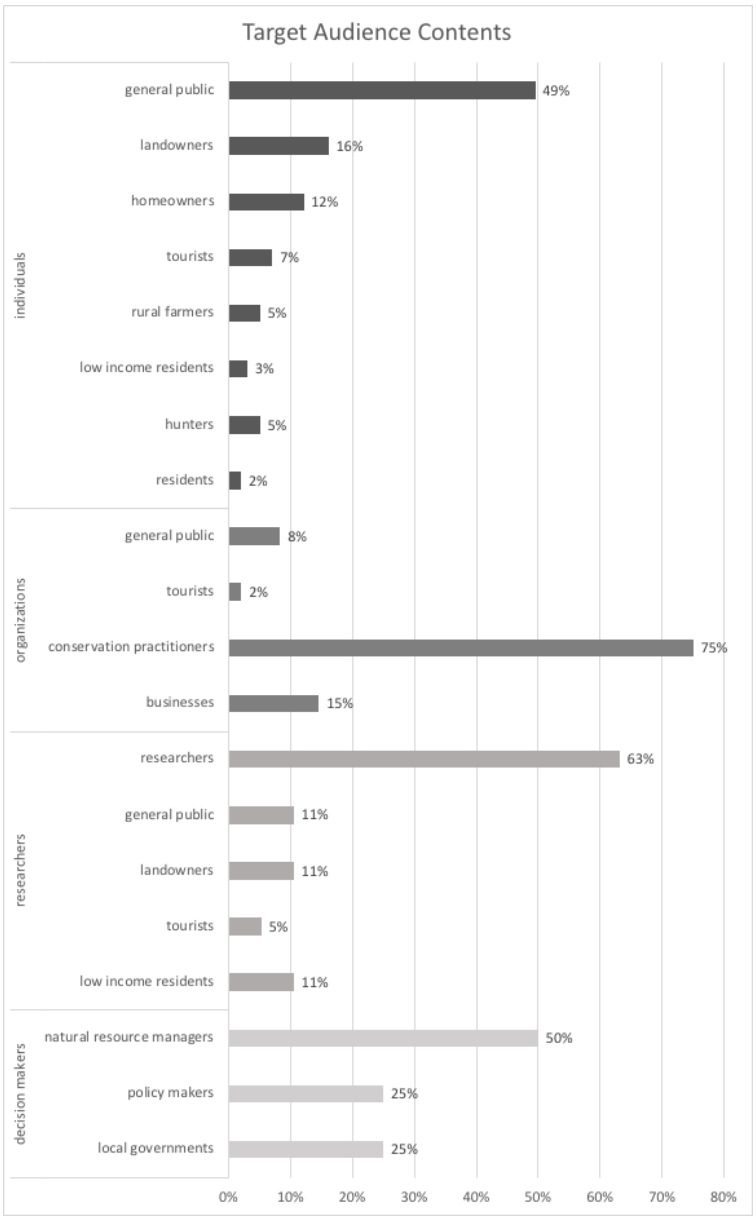
individuals
organizations
researchers

APPENDIX C: Analysis Category Contents – Chapter 1

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landowners
homeowners
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rural farmers
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5%
3%
5%
2%
organizations
general public
tourists
conservation practitioners
businesses
8%
2%
75%
15%
researchers
researchers
general public
landowners
tourists
low income residents
63%
11%
11%
5%
11%
decision makers
natural resource managers
policy makers
local governments
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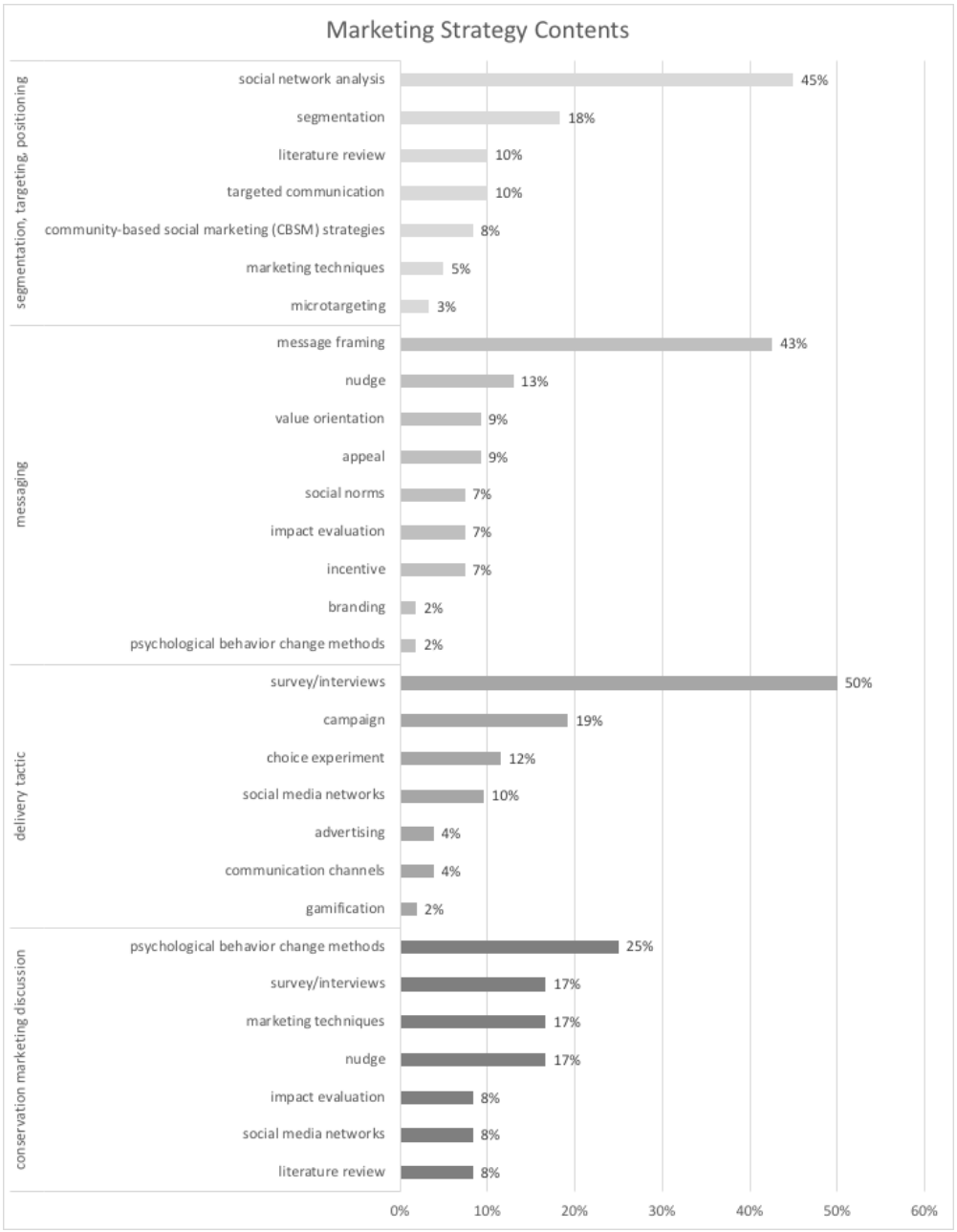
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5%
microtargeting
3%
messaging
message framing
43%
nudge
13%
value orientation
9%
appeal
9%
social norms
7%
impact evaluation
7%
incentive
7%
branding
2%
psychological behavior change methods
2%
delivery tactic
survey/interviews
50%
campaign
19%
choice experiment
12%
social media networks
10%
advertising
4%
communication channels
4%
gamification
2%
conservation marketing discussion
psychological behavior change methods
25%
survey/interviews
17%
marketing techniques
17%
nudge
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impact evaluation
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literature review
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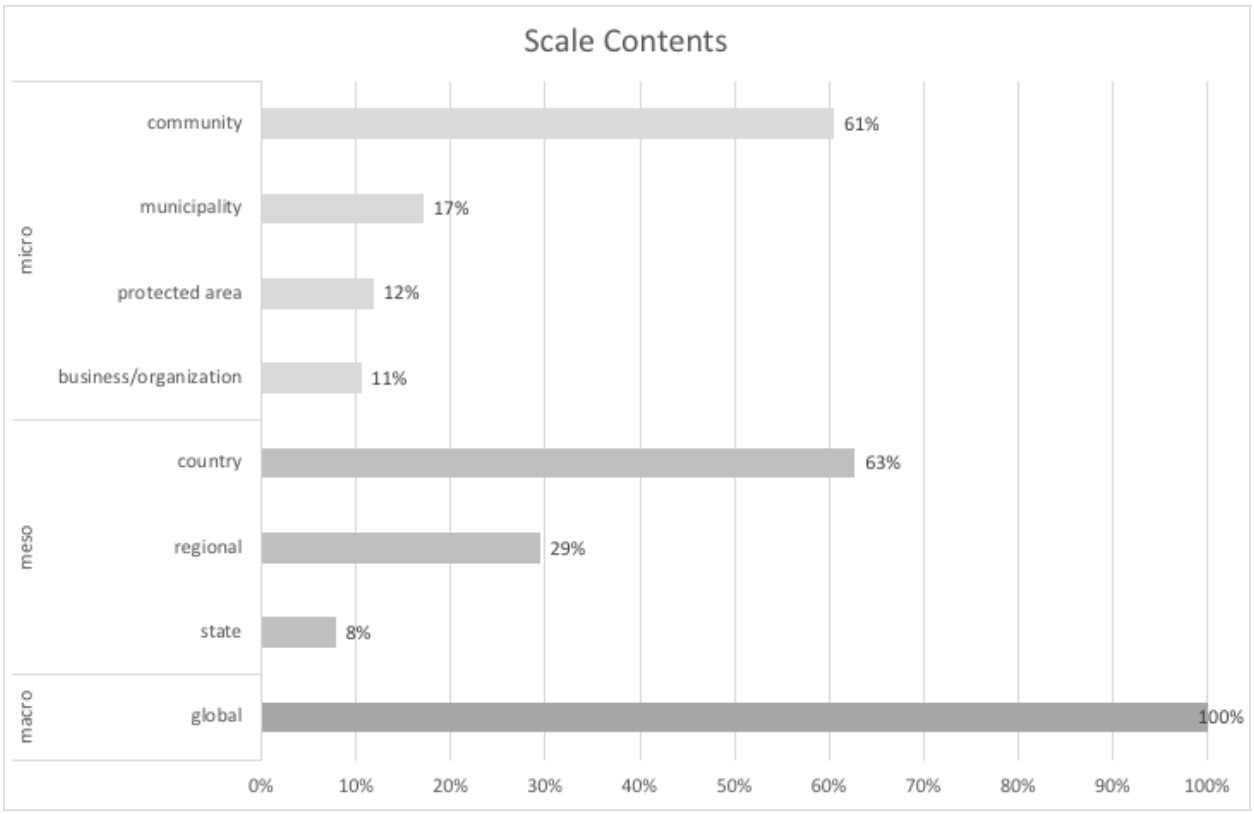
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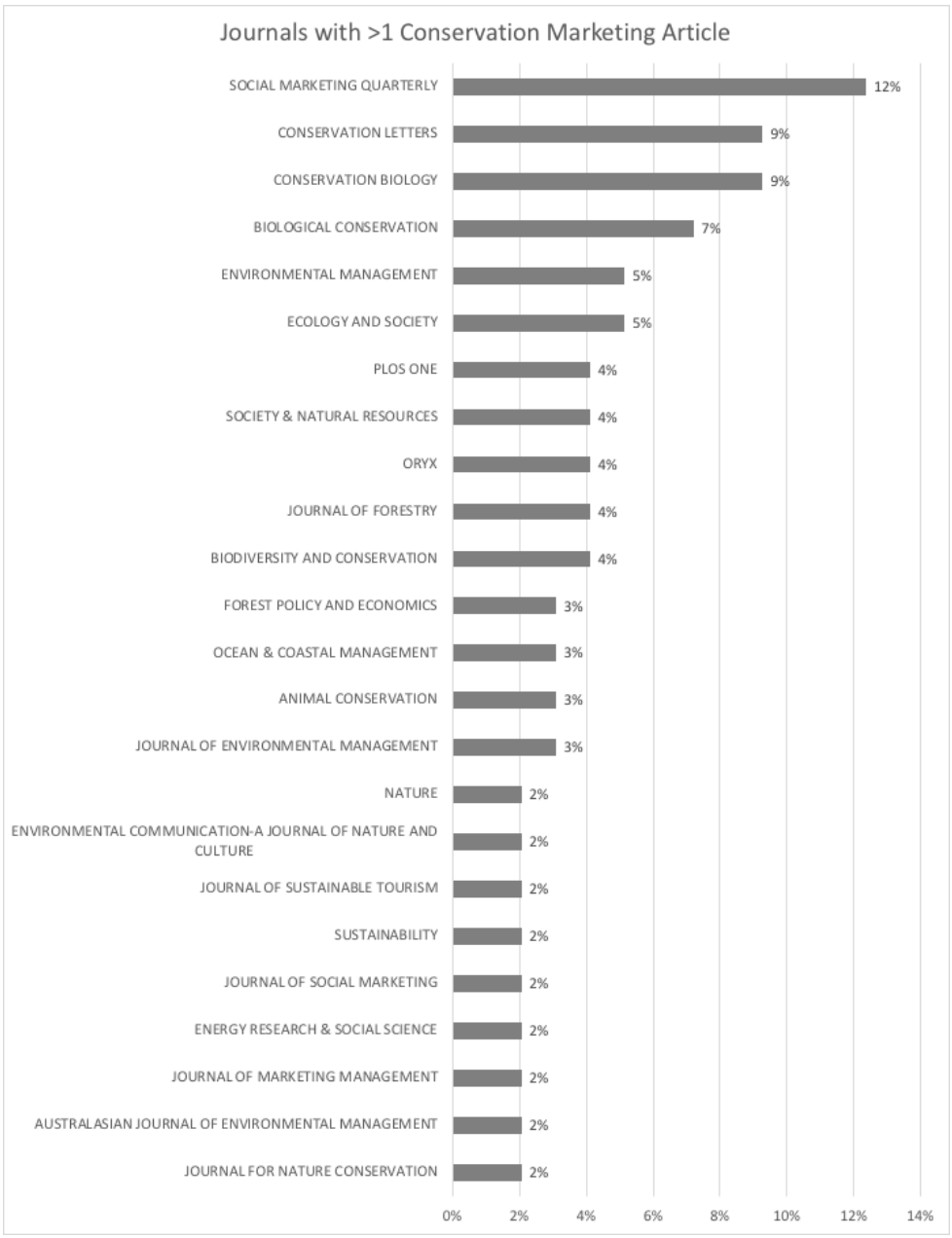
Journals with >1 Conservation Marketing Article
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CONSERVATION BIOLOGY
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ENVIRONMENTAL MANAGEMENT
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ECOLOGY AND SOCIETY
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PLOS ONE
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SOCIETY & NATURAL RESOURCES
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BIODIVERSITY AND CONSERVATION
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FOREST POLICY AND ECONOMICS
3%
OCEAN & COASTAL MANAGEMENT
3%
ANIMAL CONSERVATION
3%
JOURNAL OF ENVIRONMENTAL MANAGEMENT
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NATURE
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SUSTAINABILITY
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ENERGY RESEARCH & SOCIAL SCIENCE
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JOURNAL OF MARKETING MANAGEMENT
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AUSTRALASIAN JOURNAL OF ENVIRONMENTAL MANAGEMENT
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JOURNAL FOR NATURE CONSERVATION
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APPENDIX D: Additional Tables – Chapter 1

Country	Percent of Studies Done Outside First Author Location
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Bulgaria	0%
Canada	40%
China	0%
Colombia	0%
England	32%
Finland	20%
France	100%
Germany	60%
India	0%
Italy	0%
Japan	33%
Lithuania	0%
Malaysia	0%
Nepal	0%
Netherlands	100%
New Zealand	0%
Nigeria	0%
Norway	0%
Philippines	0%
Poland	0%
Portugal	100%
Singapore	0%
South Africa	20%
Spain	50%
Sweden	0%
Switzerland	0%
Taiwan	0%
Turkey	0%
USA	20%
Wales	0%

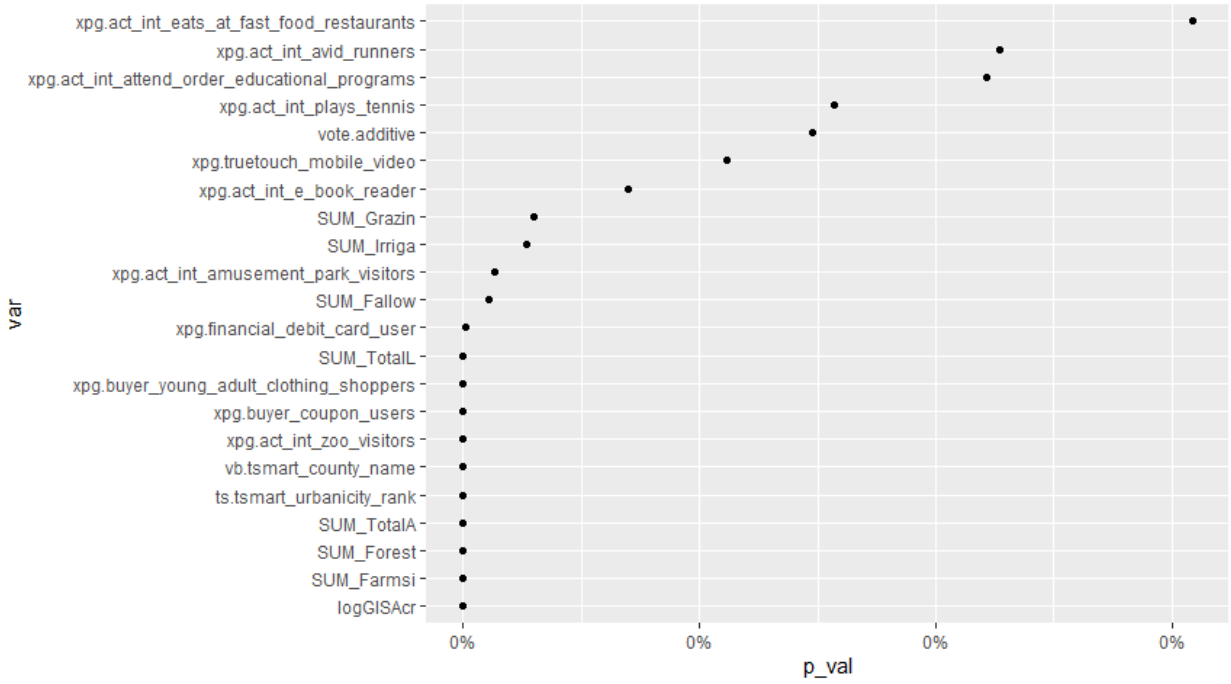
APPENDIX E: Data Dictionary Sample (full data dictionary available upon request)

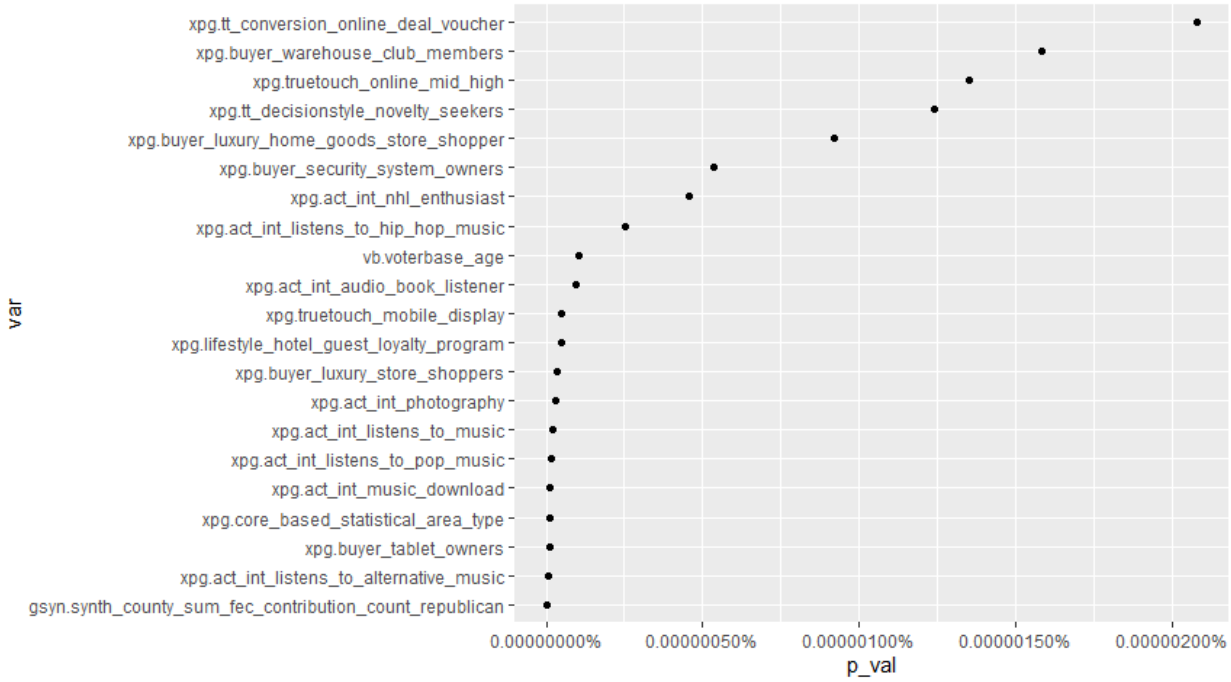
TargetSmart Communications Data Sheet

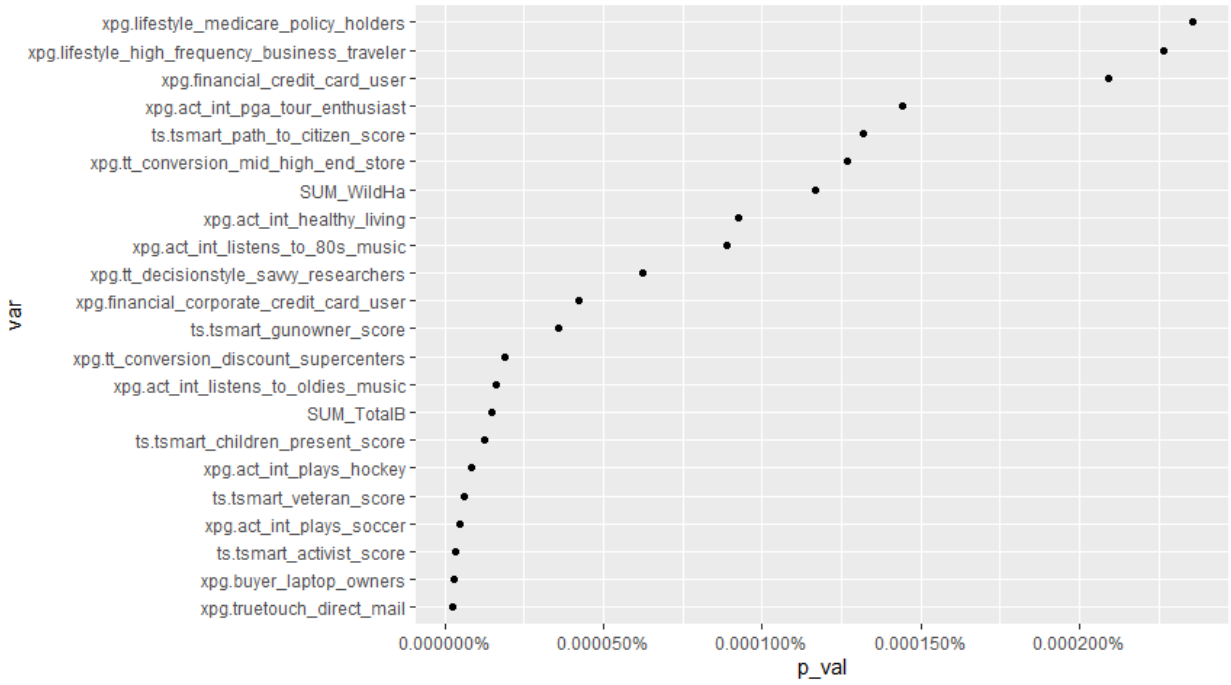
http://targetsmartcommunications.com | support@targetsmart.net | © Copyright 2020, TargetSmart Communications, LLC

Field num	Field	Field Name	Field Description	Component
1	voterbase_id	VoterBase ID	Unique identifier for VoterBase records	VoterBase
2	legal.commercial_model_usage_ok	Commercial Model Use Flag	Flag that denotes whether or not the record can be used when building Commercial Models	Metadata fields
3	meta.has_cb	Meta - ContributorBase	ContributorBase record was found for this individual	Metadata fields
4	meta.has_fec	Meta - FECBase	FECBase record was found for this individual	Metadata fields
5	meta.has_gsyn	Meta - Group Synthetics	Group synthetics record was found for this individual	Metadata fields
6	meta.has_enh	Meta - Household Synthetics	Household composition record was found for this individual	Metadata fields
7	meta.has_tb	Meta - IntelliBase	IntelliBase record was found for this individual	Metadata fields
8	meta.has_vhsyn	Meta - Vote History Synthetics	Vote History Synthetics record was found for this individual	Metadata fields
9	meta.has_xpg	Meta - Experian Gold	Experian Gold record was found for this individual	Metadata fields
10	meta.has_xpbb	Meta - Experian Behavior Bank	Experian Behavior Bank record was found for this individual	Metadata fields
11	meta.has_ts	Meta - TargetSmart Scores	TargetSmart Scores record was found for this individual	Metadata fields
12	meta.tb_match_level	Meta - IntelliBase Match Level	Indicates how the VoterBase record was matched to the IntelliBase consumer record (household, individual)	Intellibase
13	meta.xpg_match_level	Meta - Experian Gold Match Level	Indicates how the VoterBase record was matched to the Experian Gold consumer record (household, individual)	Experian Gold
14	meta.xpg_edr_hh_level_match	Experian Gold End Date Record household level match indicator	Indicates that the record has Experian Gold data populated at the household level that is sourced from the End Date Record segment. This field will be blank for records that do not match to the Experian Gold segment at the household level.	Experian Gold
15	meta.xpg_edr_individual_level_match	Experian Gold End Date Record individual level match indicator	Indicates that the record has Experian Gold data populated at the individual level that is sourced from the End Date Record segment. This field will be blank for records that do not match to the Experian Gold segment at the individual level.	Experian Gold

APPENDIX F: Likelihood-Ratio Test Outputs



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xpg.tt_conversion_mid_high_end_store
SUM_WildHa
xpg.act_int_healthy_living
xpg.act_int_listens_to_80s_music
xpg.tt_decisionstyle_savvy_researchers
xpg.financial_corporate_credit_card_user
ts.tsmart_gunowner_score
xpg.tt_conversion_discount_supercenters
xpg.act_int_listens_to_oldies_music
SUM_TotalB
ts.tsmart_children_present_score
xpg.act_int_plays_hockey
ts.tsmart_veteran_score
xpg.act_int_plays_soccer
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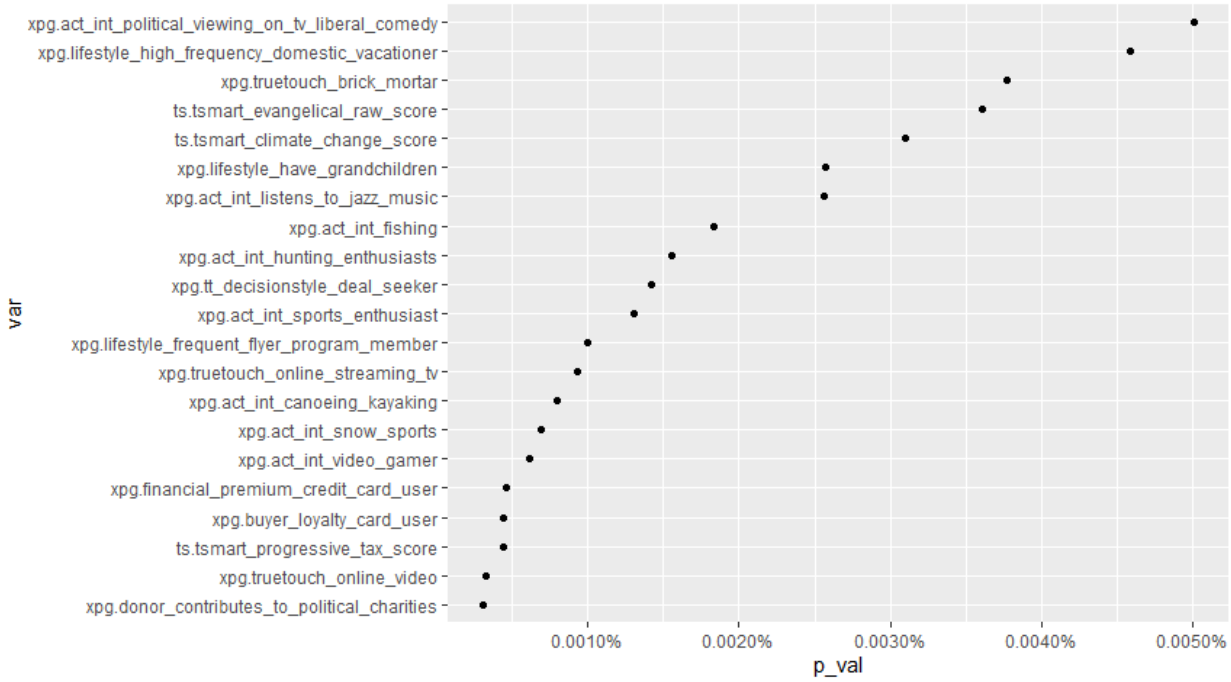
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ts.tsmart_climate_change_score
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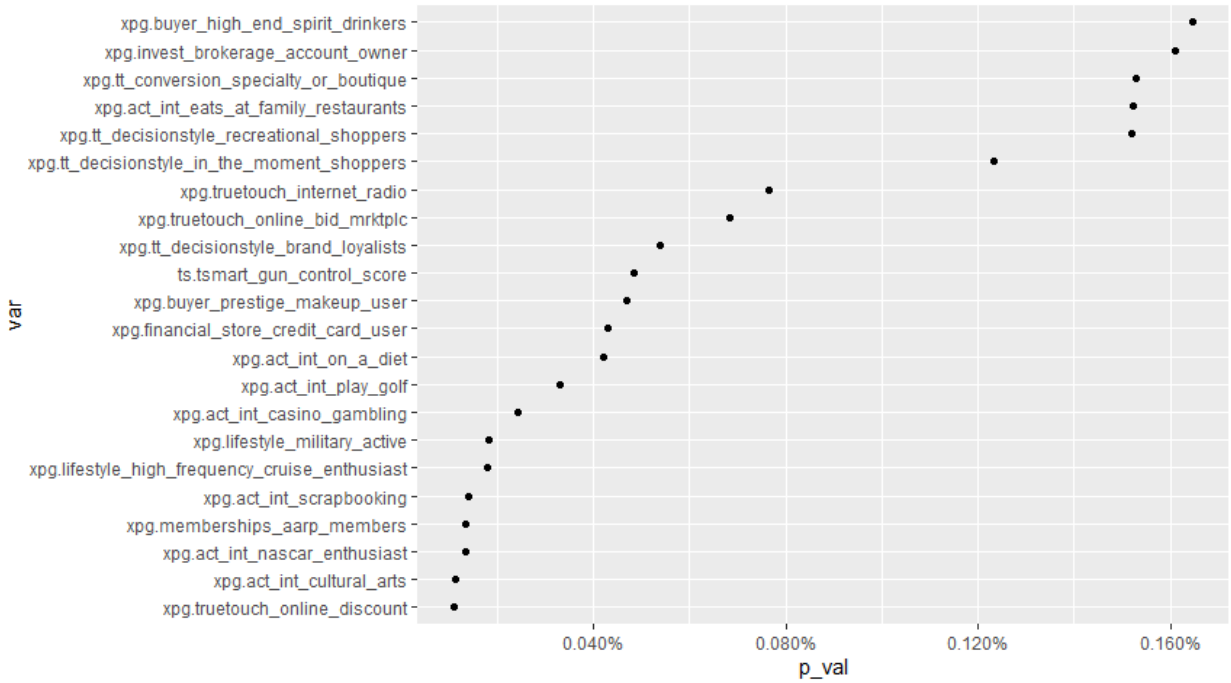
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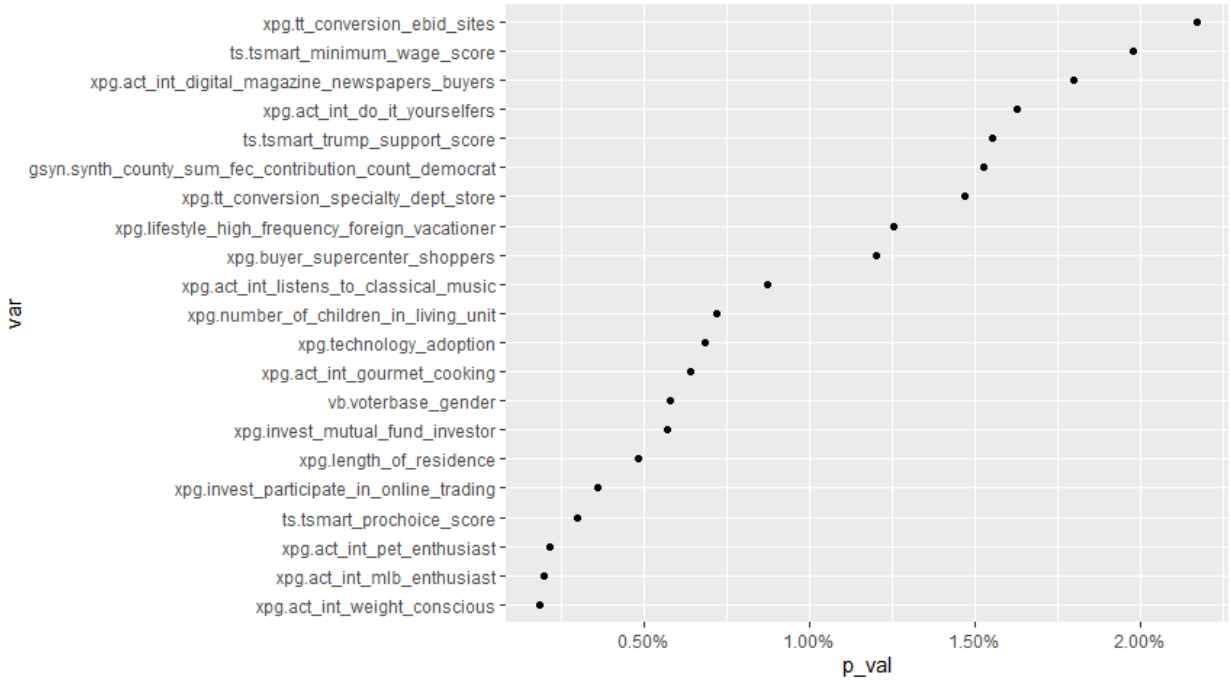
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xpg.act_int_weight_conscious
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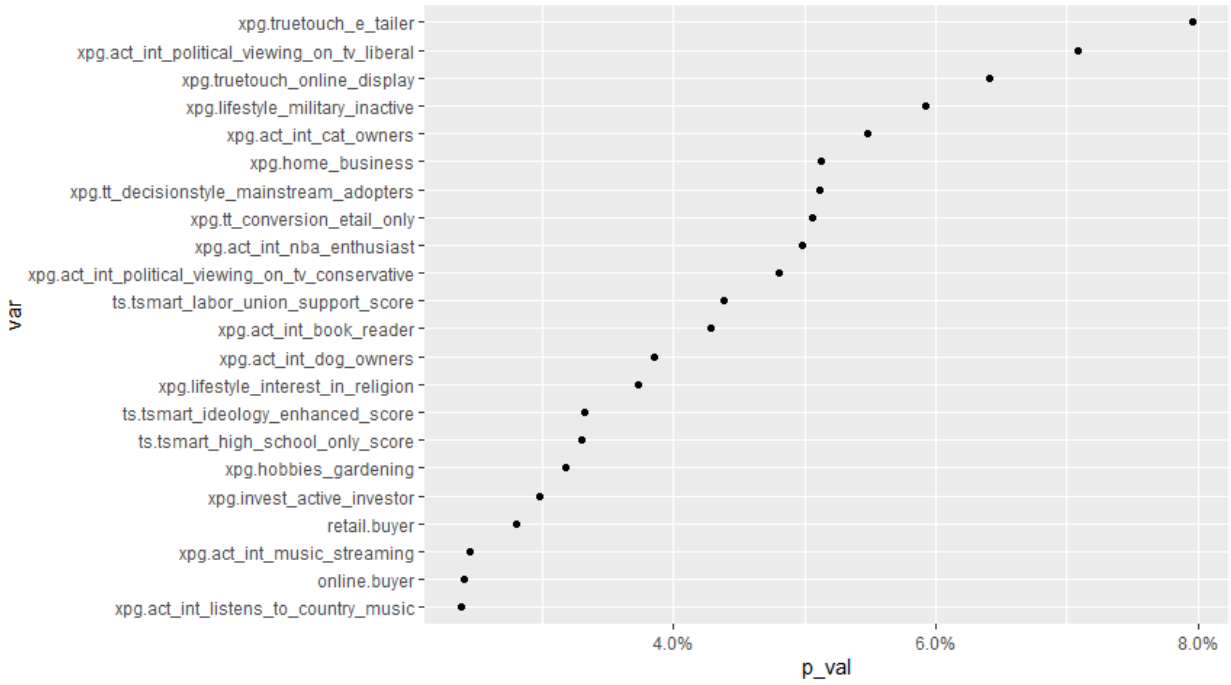
1.00%
1.50%
2.00%
p_val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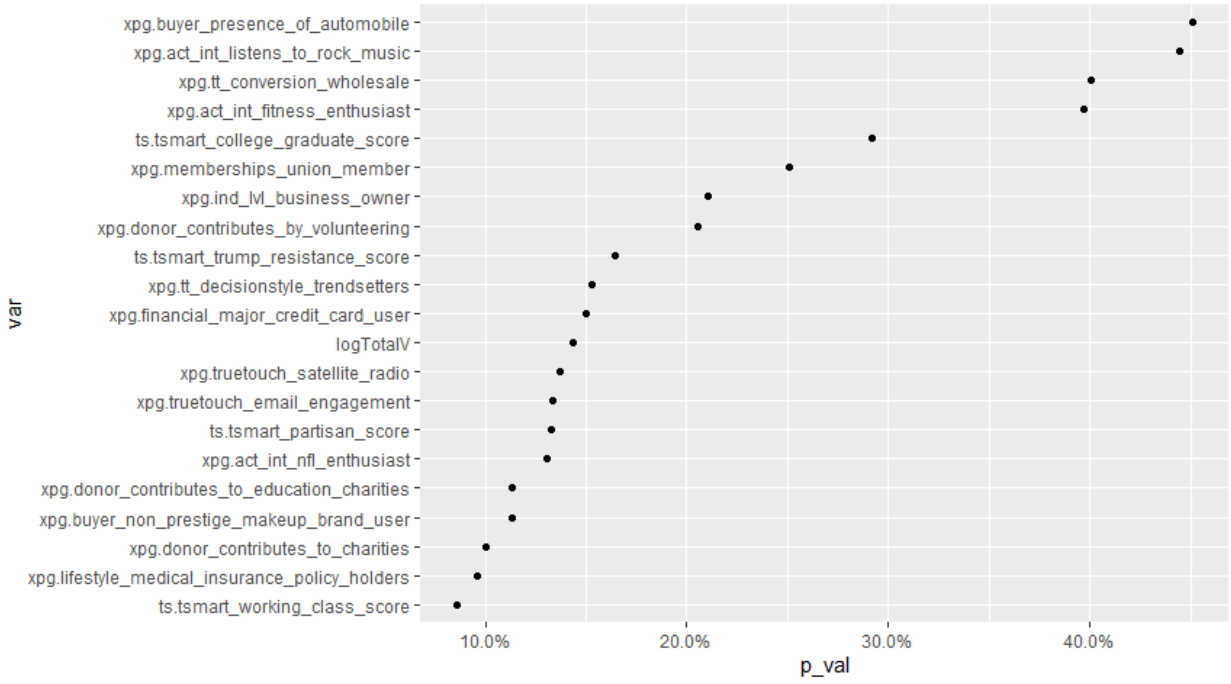
xpg.act_int_political_viewing_on_tv_liberal
xpg.truetouch_online_display
xpg.lifestyle_military_inactive
xpg.act_int_cat_owners
xpg.home_business
xpg.tt_decisionstyle_mainstream_adopters
xpg.tt_conversion_etail_only
xpg.act_int_nba_enthusiast
xpg.act_int_political_viewing_on_tv_conservative
ts.tsmart_labor_union_support_score
xpg.act_int_book_reader
xpg.act_int_dog_owners
xpg.lifestyle_interest_in_religion
ts.tsmart_ideology_enhanced_score
ts.tsmart_high_school_only_score
xpg.hobbies_gardening
xpg.invest_active_investor
retail.buyer
xpg.act_int_music_streaming
online.buyer
xpg.act_int_listens_to_country_music
var
4.0%
6.0%
8.0%
p_val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xpg.act_int_listens_to_rock_music
xpg.tt_conversion_wholesale
xpg.act_int_fitness_enthusiast
ts.tsmart_college_graduate_score
xpg.memberships_union_member
xpg.ind_lvl_business_owner
xpg.donor_contributes_by_volunteering
ts.tsmart_trump_resistance_score
xpg.tt_decisionstyle_trendsetters
xpg.financial_major_credit_card_user
logTotalV
xpg.truetouch_satellite_radio
xpg.truetouch_email_engagement
ts.tsmart_partisan_score
xpg.act_int_nfl_enthusiast
xpg.donor_contributes_to_education_charities
xpg.buyer_non_prestige_makeup_brand_user
xpg.donor_contributes_to_charities
xpg.lifestyle_medical_insurance_policy_holders
ts.tsmart_working_class_score
var
10.0%
20.0%
30.0%
40.0%
p_val