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Best Management Practices for Trapping Furbearers in the United States

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ABSTRACT Humans have used wild furbearers for various purposes for thousands of years. Today, furbearers are sustainably used by the public for their pelts, leather, bones, glands, meat, or other purposes. In North America, contemporary harvest of furbearers has evolved along with trap technologies and societal concerns, and is now highly regulated and more closely coupled with harvest analysis and population monitoring. Traps and regulated trapping programs provide personal or cultural rewards that can also support conservation, and can assist with advancing ecological knowledge through research, protecting endangered species, restoring populations or habitats, protecting personal property, and enhancing public health and safety. However, animal welfare and trap selectivity remain important topics for furbearer management in North America, as they have for more than a century. A related international challenge to modern furbearer management came with the Wild Fur Regulation by the European Union, which passed in 1991. This regulation prohibited use of foothold traps in many European countries and the importation of furs and manufactured fur products to Europe from countries that allowed use of foothold traps or trapping methods that did not meet internationally agreed-upon humane trapping standards. To address existing national concerns and requirements of the Wild Fur Regulation, the United States and European Union signed a non-binding bilateral understanding that included a commitment by the United States to evaluate trap performance and advance the use of improved traps through development of best management practices (BMPs) for trapping. Our testing followed internationally accepted restraining-trap standards for quantifying injuries and capture efficiency, and we established BMP pass-fail thresholds for these metrics. We also quantified furbearer selectivity, and qualitatively assessed practicality and user safety for each trap, yielding overall species-specific performance profiles for individual trap models. We present performance data for 84 models of restraining traps (6 cage traps, 68 foothold traps, 9 foot-encapsulating traps, and 1 power-activated footsnare) on 19 furbearing species, or 231 trap-species combinations. We conducted post-mortem examinations on 8,566 furbearers captured by trappers. Of the 231 trap model-species combinations tested, we had sufficient data to evaluate 173 combinations, of which about 59% met all BMP criteria. Pooling species, cage traps produced the lowest average injury score (common injuries included tooth breakage), with minimal differences across other trap types; species-specific patterns

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were generally similar, with the exception of raccoons (*Procyon lotor*) for which foot-encapsulating traps performed better than other foot-restraining trap types. Padded-jaw foothold traps performed better than standard-jaw models for many species, though often similar to and occasionally worse than offset- or laminated-jaw models. Most traps we tested had high capture efficiency; only 5 (3%) failed BMP standards strictly because of poor efficiency. Average furbearer selectivity was high across all trap types we evaluated and was lowest for footsnares (88%) and highest for foot-encapsulating traps (99%). Mortality from trap-related injury in restraining traps we tested was very rare for furbearers (0.5% of animals). In over 230,000 trap-nights across a 21-year period, no individuals of a threatened or endangered species were captured. Of 9,589 total captures, 11% were non-furbearers, of which 83% were alive upon trap inspection; nearly all non-furbearer mortalities were birds, rabbits, or squirrels. Approximately 2% of total captures were feral or free-ranging dogs (*Canis familiaris*), of which none died or were deemed in need of veterinary care by either our technicians or the owners (if located). Similarly, 3% of total captures were feral or free-ranging cats (*Felis catus*); 2 were dead, and although locating potential owners was often impossible, none of the remaining cats were deemed in need of veterinary care by technicians or owners. Our results show that furbearer selectivity was high for all trap types evaluated, mortality or significant injury was very rare for domestic (or feral) animals, and the most potential for mortality or injury of non-furbearers was with smaller animals, a majority of which were squirrels and rabbits. Our results suggest that injury scores for a given trap-species combination are unlikely to vary significantly across states or regions of the United States, provided similar methods are employed. Our data also suggest that taxonomic affiliation and body-size groupings are correlated with injury scores, presumably through morphological, physiological, or behavioral adaptations or responses that influence injury potential during restraint; higher injury scores in foot-restraining trap types were more likely in smaller or more dexterous species, whereas injury scores were typically lowest for the felids we evaluated. For some species (e.g., American badger [*Taxidea taxus*], bobcat [*Lynx rufus*]), most restraining traps we tested met BMP standards, whereas few restraining traps we tested met standards for other species (e.g., muskrat [*Ondatra zibethicus*], striped skunk [*Mephitis mephitis*]). Comparison of our results with survey information collected during 2015 on trap use in the United States indicates that approximately 75% of all target furbearers harvested were taken in BMP-compliant traps, with another 10% taken in traps yet to be tested on that species. Future trap testing and development should focus on commonly used traps not yet tested on a species, species for which few passing traps currently pass BMP criteria, and trap models and modifications most likely to minimize trap injuries given a species morphology, physiology, and behavior. Outreach efforts should focus on general BMP awareness, discouraging use of traps that fail BMP standards for a given species, and public outreach on trapping. Restraining (and other) traps have evolved substantially in recent decades and offer numerous benefits to individuals, conservation, and society. However, continuing to address societal concerns remains a critical component of modern regulated trapping and furbearer management. Published trapping BMPs are regularly updated online and may include additional approved restraining and killing traps that were evaluated as part of testing by Canada. We will periodically update the trap performance tables and figures we presented and make them available online at the Association of Fish and Wildlife Agencies website.

KEY WORDS animal welfare, best management practices, BMPs, cage trap, capture efficiency, conservation, footsnare, foot-encapsulating trap, foothold trap, furbearers, furbearer management, injury score, restraining device, trap selectivity, trapping.

Mejores prácticas de manejo para atrapar animales de peletería en los Estados Unidos

RESUMEN Los seres humanos han utilizado a los animales silvestres de peletería para diversos fines durante miles de años. Hoy en día, el público utiliza de manera sostenible los animales de peletería para pieles, cueros, huesos, glándulas, carne u otros fines. En América del Norte, la cosecha contemporánea de animales de peletería, ha evolucionado junto con las tecnologías de trampas y las preocupaciones sociales, y ahora está altamente regulada y más estrechamente relacionada con el análisis de la cosecha y el monitoreo de la población. Las trampas y los programas de captura regulada brindan recompensas personales o culturales que también pueden apoyar la conservación y pueden ayudar a promover el conocimiento ecológico a través de la investigación, la protección de especies en peligro de extinción, la restauración de poblaciones o hábitats, la protección de la propiedad personal y la mejora de la salud y la seguridad públicas. Sin embargo, el bienestar animal y la selectividad de las trampas siguen siendo temas importantes para el manejo de los animales de peletería en América del Norte, como lo han sido durante más de un siglo. Un desafío internacional

relacionado con la gestión moderna de los animales de peletería llegó con el Reglamento de Pieles Silvestres de la Unión Europea, que se aprobó en 1991. Este reglamento prohibía el uso de trampas que sujetan las patas (más específicamente pie y metatarso o metacarpo) de los animales en muchos países europeos y la importación de pieles y productos de piel manufacturados a Europa desde países que permitían uso de trampas que sujetan las patas o métodos de captura que no cumplieron con los estándares de captura humanitaria acordados internacionalmente. Para abordar las preocupaciones y los requisitos nacionales existentes del Reglamento Sobre Pieles Silvestres, los Estados Unidos y la Unión Europea firmaron un acuerdo bilateral, no vinculante, que incluía un compromiso de los Estados Unidos para evaluar el desempeño de las trampas y promover el uso de trampas mejoradas mediante el desarrollo de mejores prácticas de manejo (MPM) para la captura. Nuestras pruebas siguieron los estándares aceptados internacionalmente de trampas para sujetar patas (o también llamadas de restricción o contención) para cuantificar las lesiones y la eficiencia de captura, y establecimos umbrales de MPM de aceptable y no aceptable para estos parámetros. También cuantificamos la selectividad sobre los animales de peletería y evaluamos cualitativamente la practicidad y la seguridad del usuario para cada trampa, lo que arrojó perfiles generales de rendimiento sobre especies específicas para modelos de trampa individuales. Presentamos datos de rendimiento para 84 modelos de trampas de contención (6 trampas de jaula, 68 trampas para sujetar patas, 9 trampas de encapsulación de patas y 1 lazada de pata activada mecánicamente) en 19 especies de peletería, o 231 combinaciones de trampas y especies. Realizamos exámenes post mortem en 8,566 animales de peletería capturados por tramperos. De las 231 combinaciones de modelos de trampas y especies probadas, tuvimos datos suficientes para evaluar 173 combinaciones, de las cuales aproximadamente el 59% cumplía con todos los criterios de MPM. Al agrupar especies, las trampas de jaula produjeron el puntaje de lesión promedio más bajo (las lesiones comunes incluyeron rotura de dientes), con diferencias mínimas entre otros tipos de trampas; los patrones específicos de las especies fueron generalmente similares, con la excepción de los mapaches (*Procyon lotor*), para los cuales las trampas encapsulantes para las patas funcionaron mejor que otros tipos de trampas para sujetar patas. Las trampas de mandíbula acolchada funcionaron mejor que los modelos de mandíbula estándar para muchas especies, aunque a menudo son similares y en ocasiones peores que los modelos de mandíbula laminada. La mayoría de las trampas que probamos tenían una alta eficiencia de captura; solo 5 (3%) fallaron los estándares de MPM estrictamente debido a una baja eficiencia. La selectividad promedio de animales de peletería fue alta en todos los tipos de trampas que evaluamos y fue más baja para trampas para lazadas para pies (88%) y más alta para trampas que encapsulan patas (99%). La mortalidad por lesiones relacionadas con trampas, fue muy rara para los animales de peletería en las trampas de sujeción que probamos (0,5% de los animales). En más de 230,000 trampas nocturnas a lo largo de un período de 21 años, no se capturó ningún individuo de una especie amenazada o en peligro de extinción. Del total de 9,589 capturas, el 11% no fueron animales de peletería, de los cuales el 83% estaban vivos tras la inspección de la trampa; casi todas las muertes de animales no de peletería, fueron aves, conejos o ardillas. Aproximadamente el 2% de las capturas totales fueron perros salvajes o en libertad (*Canis familiaris*), de los cuales ninguno murió o se consideró que necesitaban atención veterinaria por nuestros técnicos o los propietarios (si fue posible localizarlos). Del mismo modo, el 3% de las capturas totales fueron gatos salvajes o en libertad (*Felis catus*); 2 estaban muertos y, aunque a menudo era imposible localizar a los posibles propietarios, los técnicos o los propietarios no consideraron que ninguno de los gatos restantes necesitara atención veterinaria. Nuestros resultados muestran que la selectividad de los animales de peletería fue alta para todos los tipos de trampas evaluados, la mortalidad o lesiones significativas fue muy rara para los animales domésticos (o salvajes), y el mayor potencial de mortalidad o lesiones de las especies que no fueron de peletería, fue con animales más pequeños, la mayoría de los cuales eran ardillas y conejos. Nuestros resultados sugieren que es poco probable que los puntajes de lesiones para una combinación determinada de trampas y especies varíen significativamente entre los estados o regiones de los Estados Unidos, siempre que se empleen métodos similares. Nuestros datos también sugieren que la afiliación taxonómica y las agrupaciones de tamaño corporal están correlacionadas con los puntajes de las lesiones, que se sospecha se deben a adaptaciones o respuestas morfológicas, fisiológicas o de comportamiento que influyen en el potencial de lesiones durante la inmovilización; puntajes más altos de lesiones en las trampas para sujetar patas fueron más probables en especies más pequeñas o más diestras, mientras que los puntajes de lesiones fueron típicamente más bajos para los felinos que evaluamos. Para algunas especies (p. Ej., tejón americano [*Taxidea taxus*], lince rojo [*Lynx rufus*]), la mayoría de las trampas de contención que probamos cumplieron con los estándares de MPM, mientras que pocas trampas de contención que probamos cumplieron con los estándares para otras especies (p. Ej., rata almizclera [*Ondatra zibethicus*], zorrillo rayado [*Mephitis mephitis*]). La comparación de nuestros resultados con la información de la encuesta recopilada durante 2015 sobre el uso de trampas en los Estados Unidos indica que aproximadamente el 75% de todas las especies de peletería capturadas, fueron capturadas con trampas que cumplen con las MPM, con otro 10% capturadas en trampas que aún no se han probado en esa especie. Las pruebas y el desarrollo de trampas futuras deben centrarse en las trampas de uso común que aún no se han probado en una especie, en especies para las que pocas trampas aprobadas que pasan los criterios de MP, y modelos de trampa y modificaciones que probablemente minimicen las lesiones de trampa dada la morfología, fisiología y comportamiento de la especie. Los esfuerzos de divulgación deben centrarse en la concienciación general de las MPM, desalentar el uso de trampas que no cumplan con los estándares de MPM para una especie determinada y la divulgación pública sobre la actividad de trampeo. Las trampas de contención (y otras), han evolucionado sustancialmente en las últimas décadas y ofrecen numerosos beneficios a las personas, la conservación y la sociedad. Sin embargo, seguir abordando las preocupaciones de la sociedad sigue siendo un componente crítico del manejo regulado contemporáneo de la actividad de trampeo y los animales de peletería. Las MPM sobre trampas se actualizan periódicamente en línea y pueden incluir trampas de contención y de muerte adicionales aprobadas que fueron evaluadas como parte de las pruebas realizadas por Canadá. Actualizaremos periódicamente las tablas y cifras de rendimiento de las trampas que presentamos y las pondremos a disposición en línea en el sitio web de la Asociación de Agencias de Pesca y Vida Silvestre (Association of Fish and Wildlife Agencies).

Meilleures pratiques de gestion pour le piégeage des animaux à fourrure aux États-Unis

RÉSUMÉ Les humains ont utilisé les animaux à fourrure sauvages à diverses fins depuis des milliers d'années. Aujourd'hui, les animaux à fourrure sont utilisés de façon durable par le public pour leurs peaux, cuir, os, glandes, viande, ainsi qu'à d'autres fins. En Amérique du Nord, la récolte contemporaine des animaux à fourrure a évolué avec les technologies de piégeage et les préoccupations sociales, ce qui fait du piégeage d'aujourd'hui, une pratique très réglementée et plus étroitement associée à l'analyse des récoltes et à la gestion des populations animales. De plus, les pièges ainsi que les programmes de piégeage réglementés offrent des bénéfices tant au niveau personnel qu'au niveau culturel qui permettent d'assurer la conservation, la progression des connaissances écologiques de par la recherche, la protection des espèces en voie de disparition, la restauration des populations animales et de leurs habitats, la protection des biens personnels, et l'amélioration de la santé et la sécurité publiques. Toutefois, le bien-être des animaux et la sélectivité des pièges demeurent des sujets importants pour la gestion des animaux à fourrure en Amérique du Nord, comme c'est le cas depuis plus d'un siècle. Un défi international en lien à la gestion moderne des animaux à fourrure est arrivé avec le règlement sur le piégeage et fourrures sauvages de l'Union Européenne, adopté en 1991. Ce règlement interdisait l'utilisation de pièges à rétention dans de nombreux pays européens ainsi que l'importation de fourrures et de produits manufacturés en Europe en provenance de pays qui permettaient l'utilisation de pièges à rétention ou l'utilisation de méthodes de piégeage qui ne respectaient pas les normes de piégeage sans cruauté telles que convenues au niveau international. Pour répondre à ces préoccupations et aux exigences nationales découlant du règlement sur le piégeage et fourrures sauvages, les États-Unis et l'Union Européenne ont signé un accord bilatéral non contraignant qui engageait les États-Unis à évaluer la performance des pièges et à assurer la progression vers l'amélioration des pièges via l'élaboration de meilleures pratiques de gestion (MPG) pour le piégeage. Nos tests ont été fait suivant les normes pour les pièges à rétention acceptées à l'échelle internationale en termes de quantification des blessures et de l'efficacité de la capture. Nous avons également établi des seuils de réussite et d'échec pour ces mesures en accord avec les MPG. Nous avons également quantifié la sélectivité des pièges en termes des espèces capturées, et évalué, de façon qualitative, l'utilisation pratique et la sécurité des utilisateurs pour chaque piège. Ce processus a permis d'élaborer des profils de performance spécifiques à l'espèce pour chaque modèle de piège. Nous présentons donc des données de performance pour 84 modèles de pièges (6 cages à capture vivante, 68 pièges à rétention, 9 pièges recouvre-patte, and 1lacet à propulsion mécanique) pour 19 espèces d'animaux à fourrure ou 231 combinaisons d'espèces-pièges. Nous avons effectué des examens post-mortem sur 8 566 animaux à fourrure capturés par des trappeurs. Sur les 231 combinaisons modèle-espèces de pièges testés, nous disposions de données suffisantes pour évaluer 173 combinaisons, dont environ 59% ont satisfait tous les critères MPG. Toutes espèces confondues, les cages à capture vivante ont produit le plus bas score moyen de blessures (les blessures courantes incluaient le bris de dents), avec des différences minimes entre les autres types de pièges. Les tendances spécifiques aux espèces étaient généralement semblables les unes aux autres, à l'exception des ratons laveurs (*Procyon lotor*) pour lesquels les pièges recouvre-patte ont obtenu de meilleurs résultats que les autres types de pièges à rétention. Pour de nombreuses espèces, les pièges à rétention à mâchoires cousinées ont obtenu de meilleurs résultats que les modèles de pièges à rétention standard, bien que les scores étaient souvent semblables et parfois pires que les modèles à mâchoires espacées ou à mâchoire laminées. La plupart des pièges que nous avons testés avaient une efficacité de capture élevée; seulement 5 (3%) se sont avérés non-conforme aux normes MPG et ce, en raison d'une faible efficacité. La sélectivité pour les animaux à fourrure était élevée dans tous les types de pièges que nous avons évalués et elle était la plus faible pour les lacets à patte (88%) et le plus élevé pour les pièges recouvre-patte (99%). La mortalité causée par des blessures liées aux pièges dans les pièges que nous avons testés était très rare chez les animaux à fourrure (0,5% des animaux). Sur plus de 230 000 nuits passées à piéger sur une période de 21 ans, aucun individu d'une espèce menacée ou en voie de disparition n'a été capturé. Sur 9 589 captures totales, 11% n'étaient pas des animaux à fourrures, dont 83% étaient vivants lors de l'inspection des pièges. La majorité des mortalités d'animaux n'étant pas des animaux à fourrure étaient des oiseaux, des lapins ou des écureuils. Environ 2% des captures totales étaient des chiens sauvages ou en liberté (*Canis familiaris*), dont aucun n'est mort ou n'ont été jugés avoir besoin de soins vétérinaires selon nos techniciens ou les propriétaires des chiens (dans les cas où ils ont été localisés). De plus, 3% des captures totales étaient des chats sauvages ou en liberté (*Felis catus*); 2 étaient morts, et bien que localiser les propriétaires de ces chats était souvent impossible, aucun des chats ayant survécu à la capture n'ont été jugés avoir besoin de soins vétérinaires selon nos techniciens ou les propriétaires. Nos résultats montrent que la sélectivité des animaux à fourrure était élevée pour tous les types de pièges évalués, que la mortalité ou les blessures importantes étaient très rares pour les animaux domestiques (ou sauvages) et que le plus grand potentiel de mortalité ou de blessure chez les animaux n'étant pas des animaux à fourrure était chez les petits animaux, dont une majorité étaient des écureuils et des lapins. Nos résultats suggèrent qu'il est peu probable que les scores de blessures pour une combinaison d'espèces-pièges varient de manière significative entre les États ou les régions des États-Unis, à condition que des méthodes similaires soient employées. Nos données suggèrent également que l'affiliation taxonomique et les groupements de taille corporelle sont corrélés aux scores de blessure, vraisemblablement par le biais d'adaptations ou de réponses morphologiques, physiologiques ou comportementales qui influencent le potentiel de blessure pendant la capture; des scores de blessures plus élevés dans les types de pièges à rétention étaient plus probables chez les espèces plus petites ou plus adroites, alors que les scores de blessures étaient généralement les plus bas pour les félidés que nous avons évalués. Pour certaines espèces (par exemple: le blaireau d'Amérique [*Taxidea taxus*]et le lynx roux [*Lynx rufus*]), la plupart des pièges à rétention que nous avons testés répondaient aux normes MPG, tandis que ce n'était pas le cas pour d'autres espèces (par exemple, le rat musqué [*Ondatra zibethicus*] et la mouffette rayé [*Mephitis mephitis*]). La comparaison de nos résultats avec les données d'enquête recueillies en 2015 sur l'utilisation des pièges aux États-Unis indique qu'environ 75% de tous les animaux à fourrure cibles capturés ont été capturés dans des pièges conformes aux MPG avec un 10% supplémentaire ayant été capturés dans des pièges n'ayant pas encore été testé sur cette espèce. Les tests ainsi que les développements futurs des pièges devraient se concentrer sur les pièges couramment utilisés qui n'ont pas encore été testés sur une espèce, sur les espèces pour lesquelles peu de pièges satisfont actuellement aux critères du MGP, et sur les modèles de pièges et les modifications les plus susceptibles de minimiser les blessures reliées aux pièges en fonction de la morphologie, la physiologie et le comportement d'une certaine espèce. Les efforts de sensibilisation devraient se concentrer sur la sensibilisation générale aux MPG, à décourager l'utilisation de pièges qui ne respectent pas les normes de MGP pour une espèce donnée, et à la sensibilisation du public sur le piégeage. Les pièges à rétention (entre autres) ont considérablement évolué au cours des dernières décennies et offrent de nombreux avantages aux individus, à la conservation et à la société. Cependant, continuer à répondre aux préoccupations de la société reste un élément essentiel de la réglementation moderne du piégeage et de la gestion des animaux à fourrure. Les MPG publiées sur le piégeage sont régulièrement mises à jour en ligne et peuvent inclure d'autres pièges à rétention et méthodes d'abattage approuvés qui ont été évalués dans le cadre des tests effectués au Canada. Nous mettrons périodiquement à jour les tableaux et les indicatifs de performance des pièges que nous avons présentés et les rendrons disponibles en ligne sur le site web du Fish and Wildlife Agency.

Contents

INTRODUCTION

Humans have been capturing and using wild furbearers for many purposes for thousands of years. Today, sustainable use of furbearers through regulated harvest by the public includes pelts, leather, bones, glands, meat, and other products or purposes (Ray 1987, Organ et al. 2015, Hiller and Vantassel 2021). Over time, market demands, particularly for pelts, have been substantial and fluctuated somewhat unpredictably and often species-specifically. However, muskrats (*Ondatra zibethicus*), American beavers (*Castor canadensis*), northern raccoons (*Procyon lotor*), and, more recently, coyotes (*Canis latrans*) consistently account for the majority of the wild furbearer harvest in North America (Novak et al. 1987, Responsive Management 2015). Fluctuating demand for furs or other derived products typically results in variable participation or effort by avocational trappers, making recruitment and retention of trappers a persistent and primary concern for the trapping community and wildlife managers (Armstrong and Rossi 2000). Although trends in participation had shown a decline from the mid-1980s to the mid-2000s, the estimated number of trappers in the United States grew 24% from about 142,000 in 2004 to >176,000 in 2015 (Responsive Management 2015).

Prior to 1900, unregulated and unmonitored harvest and habitat loss or degradation in North America resulted in substantial population declines, and even local extirpation, for some furbearing species. In response, the goals of early furbearer management included protective laws designed to restore populations, and regulation and monitoring of harvest (Sanderson 1982, Batcheller et al. 2000, Hiller et al. 2018). Although new challenges arise, conservation efforts continue to be successful at assisting recovery of several furbearing species (e.g., American beaver [Schulte and Müller-Schwarze 1999], fisher [*Pekania pennanti*; Lewis et al. 2012], gray wolf [*Canis lupus*; Bangs et al. 2001, U.S. Fish and Wildlife Service 2017*a*], North American river otter [*Lontra canadensis*; Raesly 2001], Sierra Nevada red fox [*Vulpes vulpes necator*; Hiller et al. 2015], swift fox [*Vulpes velox*; Kahn et al. 1997], Canada lynx [*Lynx canadensis*; U.S. Fish and Wildlife Service 2017*b*]).

Contemporary management of furbearers has evolved over the years and includes ongoing conservation efforts for rare species, regulated and sustainable harvest of abundant species, management of wildlife damage and conflict, and implementing research to address new needs (Wolfe and Chapman 1987, Batcheller et al. 2000, Hiller et al. 2018). Management agencies regularly review harvest and base recommendations for regulation changes on population trends, levels of wildlife conflicts, or other scientific evidence (Hamilton and Fox 1987, Hiller et al. 2018). For abundant furbearers, regulated harvest provides benefits to individual hunters and trappers, rural communities, society, and wildlife conservation and management (Boggess et al. 1990, White et al. 2015, Hiller et al. 2018), and is consistent with the tenets of the North American Model of Wildlife Conservation (Organ et al. 2012, 2015).

Trapping, like all human activities, is contingent upon there being a personal or societal desire, value, or need for doing so, and a sociopolitical willingness to allow it (Hampton and Teh-White 2018). In addition, where trapping is to be considered in the context of some wildlife management, conservation, or research goal, potential alternatives and effectiveness of each need to be considered. Acknowledging the complexity of these topics, we highlight some of the values and services that trapping can provide, and associated concerns with and regulatory challenges to trapping.

Financial and Cultural Benefits of Trapping to Individuals and Society

North America is currently a leading producer of wild fur, with retail fur sales >US $1.0 billion annually since 1991, and estimated at US $1.5 billion of the US $40 billion global market in 2014 (Fur Information Council of America 2015, Fur Commission USA 2016). This activity and its economic contributions to communities in the United States reportedly provides full-time employment for over 32,000 workers, and seasonal or part-time employment for an additional 155,000 workers (Fur Information Council of America 2015).

These estimates do not include the various economic benefits derived directly by avocational or nuisance control trappers, trapping supply dealers, or any associated multiplier effects. For example, approximately 177,000 licensed trappers in the United States, each spending an average of roughly $1,700 annually on trapping-related equipment (Responsive Management 2015), provided over $300 million in revenue to various businesses in 2014, in addition to conservation dollars generated through the sales of furbearer hunting and trapping licenses. Southwick et al. (2005) estimated that loss of furbearer hunting and trapping could cost United States taxpayers $132–265 million annually to address new damage and conflicts, conflicts that are often resolved through the removal of problem animals with the use of traps. Economic benefits must be weighed against potential conservation concerns, and the numbers are compelling given that modern trapping in North America is a highly regulated sustainable-use activity.

Financial and cultural benefits of trapping are often intertwined. Monetary considerations certainly play a role in fluctuations in trapper effort, but most avocational trappers do not rate income as their primary motivation for trapping (Responsive Management 2015). Rather, various personal factors often serve as the primary motivation, including interaction with nature, self-sufficiency or subsistence, and a rural lifestyle (Todd and Boggess 1987, Muth et al. 1996, Daigle et al. 1998, Zwick et al. 2007, Dorendorf et al. 2016). Although harder to quantify than financial benefits, trapping offers clear sociocultural rewards to individuals and indigenous and non-indigenous rural communities alike (Berkes et al. 1994, Brown et al. 1995, Muth et al. 1996, Daigle et al. 1998, Inoue 2001).

Indirect and Direct Benefits of Trapping to Management and Conservation

The sociocultural importance of trapping to many individuals and communities explains their desire for a close connection to the outdoors and nature interaction, and may explain why Kellert (1980) found avocational trappers to be highly knowledgeable about nature, second only to birdwatchers among the groups he compared. As such, trappers can serve as effective conservation collaborators or citizen scientists (Webb and Anderson 2016, Suffice et al. 2017). Affording the opportunity for regulated sustainable use of wildlife by those that choose to partake in the activity can expand the conservation support base and lead to stronger and more lasting support for the conservation of those species and their habitats (Hutton and Webb 2002, Prins et al. 2002, Abensperg-Traun 2009, Conrad 2012).

Whether avocational trapping plays a role in either the short- or longer-term reduction of various human-wildlife conflicts (e.g., property damage, livestock depredation, human health and safety) involving furbearers depends on many factors that vary temporally and spatially, including fluctuating pelt prices, number of active trappers, land access, and the type of conflict. Hence, broad generalizations about the effectiveness of avocational trapping at reducing human-wildlife conflicts are unwise. There are, however, sound arguments as to why avocational trapping can and does at times benefit management (Conover 2001), and strong correlative examples of extensive trapping restrictions leading to increased human-wildlife conflicts. For example, following substantial trapping restrictions, there was an estimated tripling of beaver population size in Massachusetts, USA, over 5 years and an associated significant increase in damage and complaints (Jonker et al. 2006, Organ et al. 2015).

Avocational trappers (or trapping in general) need not have population-level effects on a species, or demonstration thereof, to justify their potential role or value in reducing localized damage and conflicts. A majority of avocational trappers have been contacted by landowners to help alleviate a wildlife conflict, and 70% indicate they have assisted landowners with removal of nuisance furbearers (Responsive Management 2015). Furthermore, given that wildlife disease transmission is often density dependent, trapping, be it by avocational, incentivized, or government-employed trappers, can play a role in the reduction of disease prevalence or transmission and any associated human health and safety concerns (Todd et al. 1981, Voight and Tinline 1982, Rosatte et al. 1986, MacInnes 1987). Traps of various types are also critical tools for nuisance animal control businesses, a large and growing industry often addressing societal concerns related to property damage and human health in both rural and urban settings.

Traps and trapping are also an important component of wildlife research and conservation (Schemnitz et al. 2009). Though not all research on furbearers involves capture and handling of animals, a substantial proportion does. Traps of all types, including cage traps, foothold traps, footsnares, and cable restraints are regularly used to live restrain many species for biological data collection and subsequent animal monitoring, research that is critical to ecological understanding and conservation of species. Whether through voluntary collaboration or incentivized participation, avocational trappers often play an integral role in these capture efforts and in our experience often do so in a highly cost-effective manner; we are aware of several ongoing furbearer research projects relying exclusively on avocational trappers for animal capture (Roberts and Olfenbuttel 2019). Finally, though wildlife harvest is rarely if ever initiated or justified solely for the purpose of data collection, biologists often collect important data from harvested furbearers that are useful in managing and conserving those species (Hiller et al. 2018), again at substantially lower costs than required when obtaining the same information from targeted research projects. For example, 35 states use harvest-derived data (e.g., harvest locations, catch per unit effort, biological samples) to assist with monitoring distribution, trends, demographics, or health of North American river otters (Roberts et al. 2020), and this harvest is consistent with broader conservation goals. The International Union for Conservation of Nature considers the North American river otter, for which regulated harvest is allowed in 40 states and all provinces, a species of least concern and stable and classifies the remaining 12 species of otters occurring elsewhere in the world to be near threatened and declining at best. For many furbearers, harvest-based data are cost effective to obtain and often the only information available with sufficient sample sizes for more robust analyses regarding the distribution, abundance, and health or condition (e.g., parasite or disease prevalence, reproductive output, genetics) of the population (White et al. 2015, Hiller et al. 2018, Roberts and Olfenbuttel 2019).

Traps are also used to capture wildlife species for reintroduction or restoration efforts. This has allowed species once extirpated from portions of their historical range to return, flourish, and benefit native ecosystems. Examples of successful reintroductions in the United States facilitated by the use of the various trap types, and usually including assistance from avocational trappers, include North American river otters (Shirley et al. 1983, Serfass et al. 1996, Erb et al. 2018), gray wolves (Fritts et al. 1997), red wolves (*Canis rufus*), American beavers (Couch 1932, McKinstry and Anderson 1998), fishers (Berg 1982), American martens (*Martes americana*; Berg 1982), bobcats (*Lynx rufus*; Warren et al. 1990), and Canada lynx (Devineau et al. 2011). Trapping to reduce predation has also been shown to improve nesting success for comparatively common species (e.g., waterfowl; Anthony et al. 1991, Pieron and Rowher 2010), and more importantly, for the protection of >30 threatened or endangered species including various turtle species, whooping cranes (*Grus americana*), and many other aquatic and terrestrial species of plants and animals (see White et al. 2015 and Organ et al. 2015 for relevant examples and citations).

In addition to use in protection efforts for individual species, trapping can be an integral component in the protection of larger ecosystems. The nutria (*Myocastor coypus*), a non-native semi-aquatic mammal in the United States, has caused significant coastal marsh damage along the Atlantic coast in Maryland, the Gulf Coast sections of Louisiana, and along the coast in the Pacific Northwest. These areas provide habitat to over 15 million waterbirds, 1 million alligators (*Alligator mississippiensis*), and more than 10 threatened or endangered species. Nutria denude marshes through excessive herbivory. In Louisiana, nutria damage had been largely contained from 1962–1982 by regulated avocational trapping (Marx et al. 2004). When fur prices and avocational trapping declined in the 1980s, loss of wetlands became a growing concern. In 2002, wildlife officials in Louisiana initiated an incentivized trapping program to reduce nutria populations, supplementing the fur value with payments to registered trappers of US $4.00–$5.00 per animal. In 2003–2004, 346 trappers removed 332,596 nutrias from target areas (Marx et al. 2004). These programs have assisted in overall efforts to protect and restore large areas of fragile costal marsh ecosystems, and similar efforts have resulted in apparent eradication of nutria in Chesapeake Bay, Maryland (U.S. Fish and Wildlife Service 2016).

It is our view, similar to position statements from The Wildlife Society (2019) and the American Association of Wildlife Veterinarians (2007), that traps and regulated trapping programs provide personal or cultural rewards, can also facilitate or translate to conservation support, and can assist with advancing ecological knowledge, protecting endangered species, restoring populations or habitats, protecting personal property, and enhancing public health and safety. Traps, trapping techniques, and their associated values remain poorly understood or of concern to many people and it is imperative to continue to address concerns and knowledge gaps through public outreach, trapper education, adaptive management, ecological research, and continuing trap research and development.

Societal Concerns and Regulatory Challenges to Trapping

Public concerns about trapping are often associated with their perceptions about animal welfare and accidental captures during regulated trapping activities (Gentile 1987, Boggess et al. 1990, Andelt et al. 1999, Responsive Management 2002, Muth et al. 2006). Although trapping remains controversial, public support for regulated trapping in general is high (60–75%), but the level of support varies with the reason for capturing animals (Responsive Management 2001, 2016; Talling and Inglis 2009). Public acceptance of trapping may be increasing and higher for damage or population management than for other purposes, trends that seem consistent during past decades (Responsive Management 2001, 2002, 2016; Illinois Department of Natural Resources 2009). As noted above, however, the various motivations for trapping do not necessarily produce mutually exclusive benefits; avocational trapping or trappers can provide a cost-effective option for many wildlife conservation and management activities.

Foothold traps are very popular amongst trappers in the United States, with 86% of trappers using these devices in 2014 (Responsive Management 2015). The evolution of foothold traps has been difficult to document because early designs became popular >400 years ago and effective designs often remained in use for centuries (Gerstell 1985). Efforts to improve animal welfare and capture efficiency have also been occurring for nearly as long (Novak 1987*a*, Barrett et al. 1988, Boggess et al. 1990, Jotham and Phillips 1994). During the past several decades, ongoing improvements in traps and trapping techniques have resulted from technological advancements, scientifically based trap testing, improved trapper education programs, and regulatory refinements (International Association of Fish and Wildlife Agencies [IAFWA] 1997). Innovations include padded-, laminated-, and offset-jaw foothold traps, pan-tension devices to improve foothold trap selectivity, cable-restraints and associated breakaway (selectivity) devices (Olson and Tischaefer 2004, Association of Fish and Wildlife Agencies [AFWA] 2009, Tischaefer and Olson 2015), footsnares, lethal bodygrip (i.e., rotating-jaw) traps, foot-encapsulating traps designed to reduce injury and be highly selective for northern raccoons and Virginia opossums (*Didelphis virginiana*), and specialized cage or box traps.

In the United States, management of furbearers is under the authority of individual states and tribes, although federal management is also involved for species listed under the Convention on International Trade of Endangered Species (CITES 2013) and the Endangered Species Act of 1973 (U.S. Fish and Wildlife Service 2013). States require the flexibility and autonomy to design management programs that work within their legal frameworks, and for the diverse species, land uses, climates, and socioeconomic conditions in their jurisdiction. Given this diversity across jurisdictions, furbearer management needs and harvest regulations are spatially variable (Novak et al. 1987; AFWA 2007, 2016). However, challenges to trapping and furbearer management programs have occurred in all regions of the United States and have eroded state management authority through ballot initiatives and other legislative processes (Minnis 1998, Muth et al. 1998, Batcheller et al. 2000), and these challenges continue today (Hiller and Ahlers 2019).

An international challenge to modern furbearer management came with the 1991 Wild Fur Regulation (Regulation 3254/91) by the European Commission, designed to take effect in 1995 (European Commission 1991). Animal rights groups, following their success with an anti-sealing campaign during the 1980s against a relatively unorganized opposition (Dauvergne and Neville 2011), advanced the regulation. The Wild Fur Regulation prohibited use of foothold traps in many European countries. It also prohibited the importation of furs and manufactured fur products to Europe from countries that allowed use of foothold traps that did not meet internationally agreed-upon humane trapping standards (European Commission 1991, Hamilton et al. 1998, Harrop 1998, Andelt et al. 1999). Several issues arose with this regulation including a lack of agreed-upon humane trapping standards, and that international treaties and trade agreements are negotiated at the federal level in the United States but management authority for wildlife resides primarily with states and tribes.

Prior to the Wild Fur Regulation, Canadian officials had been working with the International Organization for Standardization (ISO) to form a multi-country (including the U.S.) technical committee of scientists and managers to develop international standards for humane trapping, including acceptable thresholds for injury from capture in restraining traps and times-to-death for species captured using killing systems (Hamilton et al. 1998). Despite failing to agree on performance thresholds (see Hamilton et al. 1998 for further explanation), the committee did eventually agree upon international trap-testing protocols for both restraining and killing traps (ISO 1999*a*, *b*).

Based on the original proposed ISO testing standards, the European Union, Canada, the Russian Federation, and the United States negotiated the Agreement on International Humane Trapping Standards (AIHTS) in 1997, which was ratified by the European Union in 1998, by Canada in 1999, and by the Russian Federation in 2008 (Council of the European Union 1998, European Commission 1998*a*, Talling and Inglis 2009). The United States did not sign this treaty agreement because of the constitutional issue related to autonomous state and tribal management authority for resident wildlife. Instead, the United States and the European Union reached an understanding memorialized as an Agreed Minute (European Commission 1998*b*), a non-binding diplomatic construct that referenced the international trap-testing standards appended to the AIHTS and the ISO standards that were under development. Furthermore, the United States conveyed by side letter the existing intent of the states to develop trapping best management practices (BMPs) for each of the 23 species of furbearing animals in North America. The United States also pledged a good-faith effort to support education and research related to improving animal welfare in United States trapping programs (IAFWA 1997, European Commission 1998*b*, Andelt et al. 1999, Fall 2002). The AIHTS and Agreed Minute were the first systematic international efforts to address concerns about animal welfare and trapping, but only the United States BMP program also included evaluation of trap efficiency, selectivity, practicality, and user safety (AFWA 2006).

Best Management Practices for Trapping

Best management practices are widely used in agriculture, forestry, and industry to promote best practices and techniques associated with specific activities. Broadly, BMPs have been described as "a method to improve an activity or set of activities by developing recommendations based on sound scientific information, while maintaining practicability" (IAFWA 1997:4). Conceptualization and early development of the trapping BMP process began prior to the European Union regulation, to proactively improve and sustain trapping and furbearer management programs, address concerns emerging within several states, and improve trapping technology in a systematic and well-documented manner. This effort was adopted in the United States by IAFWA (now known as AFWA), and the European Union regulation later added urgency to BMP development.

Because available data on species-specific trap performance were either sparse or based on varying methods, the BMP process required designing and implementing a field-based trap-testing program coordinated by AFWA and cooperating state agencies. We designed BMPs to allow integration of existing and new information into an overall set of recommendations that might facilitate jurisdictional consistency using the best available science, while recognizing the autonomy of individual states for implementation (IAFWA 1997).

As part of developing trapping BMPs, we (now the AFWA Furbearer Resources Technical Work Group) established thresholds for certain trap-performance criteria (detailed in Methods). We developed these thresholds consistent with the procedural standards annexed to the 1997 understanding reached between the United States and the European Union (European Commission 1998*b*). Specific thresholds provide a common framework for evaluating traps, and hence progress toward the use of traps and trapping methods that meet animal welfare (and other) criteria.

Our broad objectives for the trapping BMP program were to 1) evaluate the performance of traps using a standardized, science-based, national-scale, and multi-species testing program; 2) stimulate continued development of improved trapping systems with respect to animal welfare, efficiency, and selectivity; 3) develop BMPs and encourage use of BMP-compliant devices by all trap users; 4) meet United States obligations pursuant to the Agreed Minute with the European Union; and 5) provide effective outreach to better demonstrate and maintain trapping (in its many forms) as a sustainable use of natural resources and an important tool for wildlife research and conservation, and human-wildlife conflict resolution. We focused on presenting 1) methods and processes used in development of BMPs, 2) species-specific trap performance, and 3) broad-scale patterns in trap performance metrics.

STUDY AREA

To address differential trap use across the United States (Responsive Management 2015) and to encompass a diversity of field conditions (e.g., land uses and cover types, weather, soil conditions) that may affect trap performance, we designed our study to include field testing in numerous states, and where appropriate and possible, in different regions we delineated within the United States (Fig. 1). We selected study sites primarily based on population levels of the species of interest, levels of participation interest by individual state wildlife agencies, potential differences in biotic and abiotic conditions that may affect trap performance, and regulatory considerations.

Major land-use, land-cover types in Alaska (>1.7 million km^2) included shrub-scrub (24.6%), dwarf shrub (18.6%), evergreen forest (14.9%), and barren land (8.4%; Fry et al. 2011). Based on the Köppen climate classification, Alaska includes areas with primarily snow and cool, dry summers, snow with cool fully humid summers, and polar tundra (Chen and Chen 2013). Alaska had a human population of about 714,000 during 2010 (U.S. Census Bureau 2016).

The Great Plains-West region encompasses about 3.7 million km^2 and had a human population of about 86.3 million (U.S. Census Bureau 2016). Major land-use, land-cover types included shrub-scrub (44.3%), grassland-herbaceous (18.5%), evergreen forest (18.1%), and cultivated crops (7.3%; Fry et al. 2011). Climate in this area is diverse but included snow with fully humid and cool or hot summer (mountainous areas), dry with dry summers and cold arid climate (interior non-mountainous areas), and mild temperatures with dry (warm or hot) summers (coastal areas; Chen and Chen 2013).

The midwestern portion of the United States covers about 2.3 million km^2 with a human population of 70.7 million (U.S. Census Bureau 2016). Major land-use, land-cover types included cultivated crops (36.7%), grassland-herbaceous (20.0%), deciduous forest (14.0%), and pasture-hay (10.4%; Fry et al. 2011). The area is characterized by a dry, cold and arid climate with dry summers in the west; snow with fully humid, hot summers in the central section; and mild temperatures with fully humid, hot summers in the south (Chen and Chen 2013).

The northeastern portion of the United States covers 0.5 million km^2 with a human population of 62.7 million (U.S. Census Bureau 2016). Major land-use, land-cover types included deciduous forest (34.4%), mixed forest (11.9%), evergreen forest (9.6%), and pasture-hay (9.3%; Fry et al. 2011). This area is dominated by mild temperatures with fully humid, hot summers, with the far northern section including snow with fully humid, warm summers (Chen and Chen 2013).

The southeastern portion of the United States has about 87.5 million humans within about 1.6 million km^2 (U.S. Census Bureau 2016). Major land-use, land-cover types included deciduous forest (23.0%), evergreen forest (13.8%), pasture-hay (12.7%), and woody wetlands (11.2%; Fry et al. 2011). Climate in the southeastern United States is predominately mild temperatures with fully humid, hot summers (Chen and Chen 2013).

Figure 1. The study area used for trap testing to develop best management practices for trapping included the conterminous states and Alaska, USA, 1997–2018. We conducted testing of each trap model in ≥1 or more of 5 regions: Alaska (AK), Great Plains-West (AZ, CA, CO, ID, MT, NV, NM, OR, western TX, UT, WA, WY), Midwest (IL, IN, IA, KS, MI, MN, MO, NE, ND, OH, OK, SD, WI), Northeast (CT, DE, ME, MD, MA, NH, NJ, NY, PA, RI, VT), and Southeast (AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, eastern TX, VA, WV).

METHODS

Because the initial focus of research conducted by parties to the AIHTS, primarily Canada, was the evaluation of killing-trap performance pursuant to ISO protocols, the United States BMP research program focused on evaluation of live-restraining traps. Nonetheless, killing trap welfare (time-to-death) data collected in Canada (Fur Institute of Canada 2017*a*) were shared with us and traps were included in BMPs if they met our thresholds for welfare and efficiency; data on killing-trap efficiency were collected as part of BMP research in the United States. Because we are not at liberty to publish the killing-trap welfare data collected by Canada, we report only our research on performance of live-restraining traps.

Types of Restraining Traps

Restraining traps are capture devices "…designed and set with the intention of not killing the trapped animal, but restraining its movements to such an extent that a human can make direct contact with it" (European Commission 1998*b*:28). We evaluated 4 types of restraining traps for mammals: foothold traps, foot-encapsulating traps, cage traps, and 1 model of spring-activated footsnare (Fig. 2; see Proulx 1999 and AFWA 2006 for comprehensive trap descriptions). Systematic testing on a fifth type of live-restraining trap, cable-restraints, is ongoing and results will be published separately when sufficient data have been collected.

Foothold traps (Figs. 2A and 2B) typically have 2 jaws that are 180 degrees apart when in the set position (Fig. 2B [left]), and close to 90 degrees when the trap is activated (Fig. 2B [right]). We tested numerous models of foothold traps with different types of jaws (Fig. 3). Footsnares (Poelker and Hartwell 1973, Englund 1982, Skinner and Todd 1990, Shivik et al. 2000) are spring-activated cables used to capture and hold medium- and large-sized mammals by a foot (Fig. 2C). Cage traps are manufactured in an array of sizes suitable for many mammalian species (Fig. 2D), and are constructed of wire or nylon mesh, wood, plastic, or metal, with a treadle or other triggering device that activates ≥1 gravity- or spring-operated door. Foot-encapsulating devices generally have a reach-in pull-trigger that

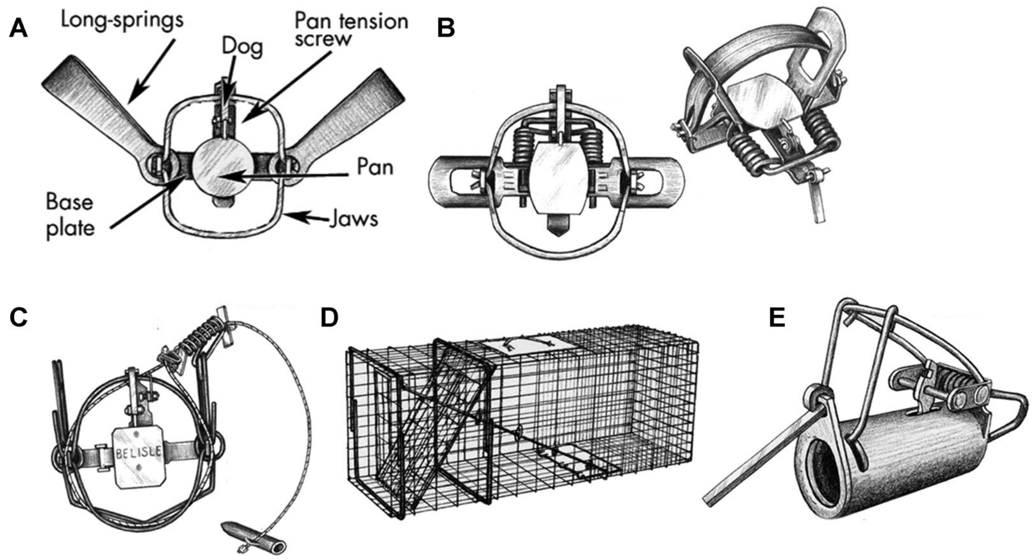

Figure 2. Examples of restraining traps tested during development of best management practices for trapping included the A) double-longspring foothold trap (with description of major components), B) coil-spring foothold trap (left = activated), C) power-activated footsnare, D) wire-mesh cage trap, and E) foot-encapsulating trap.

releases a small rod or plate that secures the animal's foot against and inside a plastic or metal trap housing designed to protect the captured limb from torsion or self-directed biting (Fig. 2E); a few models have triggers that activate using either a push or pull trigger design. Foot-encapsulating traps were designed by trappers to selectively capture raccoons with minimal injury.

Prioritizing Testing Efforts

We conducted a comprehensive survey of state and provincial wildlife agencies (IAFWA 1992) to collect information on ownership and use of traps, costs of wildlife damage control, and trapping regulations. Based on these results, a review of published literature, and consultation with experienced trappers, veterinarians, and statisticians, we designed and implemented a long-term, nationwide study to evaluate traps and trapping systems. We initially prioritized testing of individual models of restraining traps based on their commercial availability, relative use among trappers both regionally and nationally, and potential benefits for addressing concerns about animal welfare.

We also prioritized testing on the 23 furbearing species listed in the Agreed Minute based on numerous criteria (e.g., magnitude and economic value of harvest, level of wildlife conflicts, quality of existing data) and ranked testing for each species as high, medium, or low priority (Table 1; IAFWA 1997). The prioritization process resulted in testing a large number of restraining traps for some furbearing species, and few models for

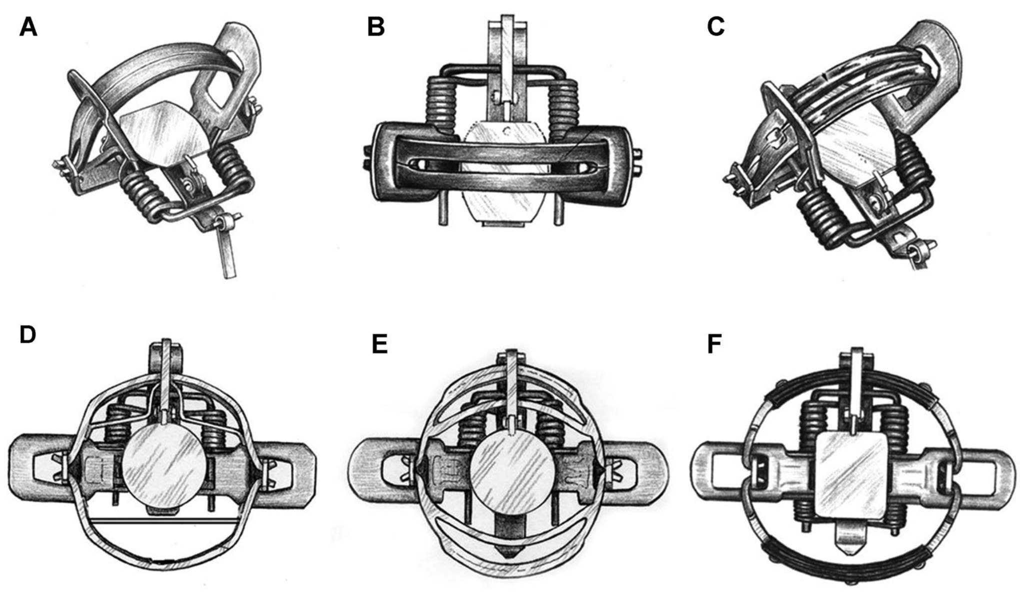

Figure 3. Examples of different types of jaws on foothold traps: A) standard, B) offset, C) offset and outside-laminated, D) asymmetrical double, E) symmetrical double, and D) padded.

Table 1. Priority ranking for best management practices trap testing on furbearing species in the United States, 1997–2018. Rankings were based on factors such as number harvested, number of conflicts with humans, and quality of existing data. Asterisk denotes species for which testing of live-restraining devices has been conducted.

High	Medium	Low
American and Pacific marten	American badger*	Arctic fox*
American mink	American beaver*	Canada lynx*
Coyote*	Bobcat*	Ringtail*
Gray fox*	Fisher*	Weasel spp.
Muskrat*	Gray wolf*	Wolverine
Northern raccoon*	North American river otter*	
Nutria*	Striped skunk*	
Red fox*	Swift fox and kit fox*	
	Virginia opossum*	

other species. For example, no BMP testing has been conducted using foothold traps for live restraint of American (or Pacific [*Martes caurina*]) marten, American mink (*Neovison vison*), or weasels (*Mustela* spp.) because these sets are not commonly used for these species (Responsive Management 2015). Similarly, testing of restraining traps was comparatively limited for some semi-aquatic species (e.g., American beaver, muskrat) because most trapping for these species uses either lethal bodygrip traps (Responsive Management 2015) or lethal trapping systems (e.g., submersion systems incorporating foothold traps). In addition, though we have commenced with an effort to develop a wolverine (*Gulo gulo*) trapping BMP, we have not yet tested any live-restraining traps on this species.

Field Data Collection

We collected furbearers from trappers in 33 states and across all regions of the United States from 1997–2018 (Tables S3–S38, available online in Supporting Information). We followed standardized testing protocols established by ISO (1999*b*) for restraining traps, as described in the Agreed Minute between the United States and European Union (European Commission 1998*b*). We used 2-person teams that consisted of 1 trapper and 1 field technician to test ≥1 model of restraining trap on each testing project we conducted. Through various agreements, experienced state-licensed avocational trappers participated in the effort and provided animals they had captured during normal regulated trapping seasons in their state. Trappers followed any manufacturer's instructions for the restraining traps and used their own knowledge and experience in the field. Technicians trained in the field protocol accompanied trappers to record data, mark captured furbearers, and ensure that trappers followed the study design. We recruited up to 4 trapper-technician teams in each participating state for each testing project. We prioritized recruitment of participants in areas with relatively abundant populations of the species of interest, and selected experienced trappers willing to participate in their state or region. When possible, we also selected trappers from different geographic locations within a state or region to encompass a broader range of trapping conditions.

To avoid confusion or potential bias, we trained each team to follow our study design and, when necessary, familiarized them with the specific models of restraining traps being evaluated. We trained technicians to collect data, maintain accurate records on standardized data sheets, and label and prepare animals for post-mortem examination. To gain additional insight into trap performance, we also interviewed trappers at the end of each trap-testing period.

We instructed technicians to ensure that trappers set traps in pairs, which we refer to as a trap station (Fig. 4). To avoid trap-selection bias, each trapper selected a location for a trap station and then the technician randomly assigned a specific restraining trap (i.e., manufacturer, model, size; hereafter, trap model) from the set of trap models (Appendix A) they were testing. Trap locations within a trap station were 3–10 m apart at the discretion of the trapper. Trap stations were a minimum distance of either 30 m (for Canada lynx in Alaska, coyotes in the Great Plains-West region, and northern raccoons in all regions) or 100 m (all other instances) apart to increase spatial independence. The reduced distance for some species-region combinations was intended to accommodate typical trap setting practices (i.e., multiple traps in patches of good habitat) that trappers preferred in those situations, relying on the local landscape features (e.g., dense cover, topography, creek banks, waterway sinuosity) often present in those areas to help ensure reduced visibility or behavioral influence of other animals captured at nearby trap stations. After a trapper established all of their trap stations, they selected 2–4 alternative locations for trap stations to allow for relocation of traps during testing, if

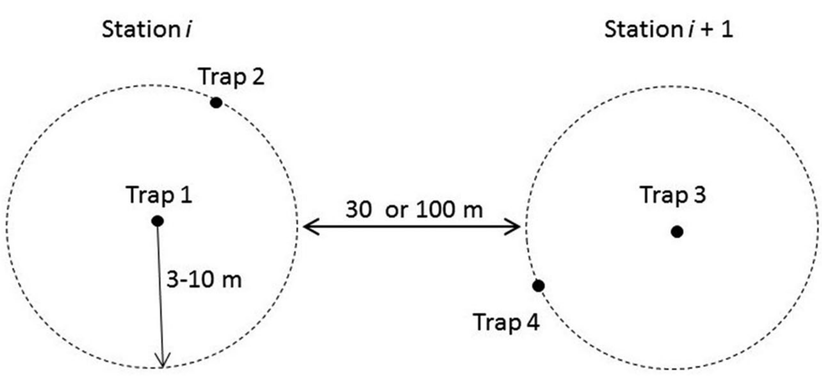

Figure 4. Trap-placement design for live-restraining devices used on furbearers during development of best management practices for trapping in the United States, 1997–2018. Each trapline consisted of a series of stations, with distance between pairs of stations either 30 m (raccoons, coyotes, Canada lynx) or 100 m (all other species).

necessary. A trapper could relocate a trap within the boundary of a given trap station at any time, but if a trapper relocated a trap outside of a trap station, the design specified that both traps be relocated. If an alternative location for a trap station was necessary, the technician randomly selected 1 of those alternatives for the trapper.

Testing of individual trap models proceeded for a predetermined duration (usually 10, 14, or 21 days) that was dependent on the estimated time required to meet capture quotas assigned to individual trappers. If a trapper met their capture quota for the focal species before the end of the time allocated, the team ceased collecting animals. If an individual trapper was unable to meet their capture quota, we asked 1 or more trappers within that state or region to capture more than their quota to meet minimum desired sample sizes.

We required trappers to check each trap and remove any animals once each day before 1200 hours. Trappers used a gunshot (.22-caliber) to the head to dispatch furbearers captured in restraining traps (Sikes et al. 2011, American Veterinary Medical Association 2013). This method ensured rapid death and avoided damage to teeth, legs, or other body parts that could influence subsequent assessment of trap-related injuries. In an attempt to minimize spraying during 1 skunk-focused field project, trappers used hypoxia to dispatch striped skunks (*Mephitis mephitis*) captured in cage traps; they placed individual skunks in a closed chamber and exposed them to high concentrations of carbon dioxide (American Veterinary Medical Association 2013).

Technicians recorded information such as the species captured and restrained in the trap until inspection, any species captured but not restrained until inspection, any traps activated with evidence of a potential capture, any traps activated with no evidence of a potential capture, and any trap sites disturbed but with the trap not activated. For each dispatched furbearer, technicians recorded the foot (for foot-restraining trap types) by which the animal was restrained, the capture position on that foot (e.g., toe, metatarsal or metacarpal pad, wrist), and its physical condition (i.e., alive, dead, unconscious) when they checked the trap. Because our restraining-trap research was focused on injuries (including death) associated with the trap itself, we excluded from analysis animals that were already dead (or injured) upon trap inspection as a result of uncontrolled external variables (e.g., shot by another person, attacked by other animals, hypothermia, accidental drowning). However, if there was no apparent cause of death (e.g., bite marks, bullet hole, dead animal in water), we assumed the death was from trap-related stress or injury. Technicians marked each dispatched furbearer with a unique identification number, secured the animal in a sealed plastic bag, and placed it in a freezer until post-mortem examination by a wildlife veterinary pathologist. Trappers released non-furbearing species (domestic or wild) and any furbearers with closed seasons or otherwise not legal to trap at that time in the state where testing occurred. Technicians ensured that any captured domestic dog (*Canis familiaris*) or cat (*Felis catus*) was returned to the owner, when located, and received any necessary medical treatment.

We often designed testing projects for 1 focal species, but on many projects, trappers set traps targeting multiple furbearing species to allow trapping methods they commonly employed, and to increase overall BMP project efficiency. Exceptions included testing on Arctic foxes (*Vulpes lagopus*) and gray wolves, which always targeted a single species. Because of their more limited distribution (Audet et al. 2002) and logistical challenges, we captured Arctic foxes on Saint George Island, Alaska, under a scientific collection permit (#15-026) issued by the Alaska Department of Fish and Game and a Land Use Permit issued by the Saint George Tanaq Corporation, and with permission of the Saint George Tribal Council. Most gray wolves were captured outside normal harvest seasons as part of authorized depredation control programs in the lower 48 states. Therefore, data collected while trapping gray wolves may not be reflective of seasonal conditions (e.g., species availability, behaviors) normally experienced on avocational traplines. Open-access species-specific BMP documents (AFWA 2017*a*) may include additional models of restraining devices, a result of ongoing research and because testing of a few restraining devices occurred exclusively by Canada through the AIHTS (Fur Institute of Canada 2017*b*) and we are not at liberty to publish those data.

Laboratory Data Collection

Wildlife veterinary pathologists, many already experienced with evaluating trap-related injuries, cross trained on established procedures to conduct comprehensive whole-body post-mortem examinations of captured furbearers. To avoid potential bias, pathologists had no knowledge of the trap model used for any specimens prior to examination, or (for foot-restraining traps) the specific foot by which the animal had been restrained. On a random sub-sample of specimens, pathologists used information from x-ray of limbs to verify visual observations during examinations. Pathologists reported results using ISO methods for scoring specific injuries from restraining traps (ISO 1999*b*). Although not assigned injury points in and of itself, we also noted presence or absence of any self-directed biting on all animals during post-mortem examinations.

Criteria to Evaluate Restraining Traps

We evaluated restraining traps based on 2 quantitative criteria (animal welfare, capture efficiency) that had threshold values for approval in the BMP program. We required a minimum sample size of 20 individuals of a given furbearing species per trap model (European Commission 1998*b*) to evaluate animal welfare and capture efficiency. An exception to this could occur when the sample size was nearly met (e.g., ≥17) but injury scores were such that collection of additional samples to reach the minimum of 20 was unlikely to have changed the animal welfare pass-fail status of that trap. Although we did not develop a hard rule, our exception assessment was based on comparison of the maximum (or minimum) score that each additional animal would need to have to alter the pass-fail status of the trap to the observed maximum (or minimum) for that trap-species combination; details of any exceptions ($n = 2$) are provided in species-specific results.

We also computed a quantitative measure of furbearer selectivity, though we did not establish a selectivity threshold value for approval in the BMPs. The BMP process also included

2 qualitative criteria (practicality, user safety) that we do not discuss further except to note that we did not exclude any restraining devices from BMPs solely because of either of these criteria.

Animal welfare.—We acknowledge that the issue of animal welfare is complex and involves physical injury and other considerations (e.g., pain, distress). However, we selected injury as the primary criterion to evaluate animal welfare based on the recommendations of ISO. Other potential methods or components of welfare might include criteria related to behavior, physiology (stress), immunology, and molecular biology, but the ISO process concluded there was insufficient knowledge or technology to incorporate those potential metrics (ISO 1999*b*: Annex A, Scope 1, paragraph 1.2). Likewise, we remain unaware of any cumulative metric that encapsulates all of these considerations, can be reliably measured in typical field situations, and that is science-based with a broadly accepted threshold for acceptance. For these reasons, we focused on quantifying and comparing injury levels across trap models using standardized ISO scoring protocols, with a goal of improving animal welfare in trapping.

The ISO testing-standard development did not result in international agreement on acceptable injury thresholds (Hamilton et al. 1998) but described 2 trauma scales for summarizing injury (ISO 1999*b*). The first method uses a cumulative point-scoring system for injuries and assigns points (0 to 100; Table 2; see also Table S1, available online in Supporting Information) to each specific injury incurred. The second system uses ISO trauma categories (mild, moderate, moderately severe, and severe) pre-determined (Table 2) for each injury.

We derived BMP criteria and thresholds based on the level of injury that we deemed unlikely to directly or indirectly (i.e., through behavioral changes) have a meaningful effect on subsequent survival or reproduction for >70% of the animals. The ISO injury assessment requires whole body examination of dead animals, so we were unable to correlate observed injury scores with subsequent survival and reproduction of trapped animals. Instead, we relied on expert opinion of some individuals on our committee who had been involved in the ISO process, along with that from other experienced biologists and wildlife veterinary pathologists in the United States. Per ISO protocol, we recorded and assigned each injury the associated ISO injury score and to the associated injury class (Tables 2 and S1). We then calculated a cumulative injury score for each individual and the average cumulative injury score for each species-trap combination. We adopted a 2-part BMP threshold that takes into account the most severe injury an animal sustained and the totality of injury. For a trap model to meet BMP welfare criteria for a species, the mean cumulative injury score must be ≤55 points (hereafter, injury-score criterion) and ≥70% of individuals in the sample must have either no injuries, or injuries categorized only as mild or moderate (hereafter, lower-trauma criterion).

Capture efficiency.—We calculated species-specific capture efficiency for each trap model as the number of captures of the focal species divided by the number of potential captures of that species (described as capture rate in ISO [1999*b*]). We defined a potential capture to be when a given species activated a trap and 1) was never restrained, 2) was captured but not restrained until trap inspection, or 3) was captured and restrained until the trap was inspected (Linscombe and Wright 1988, Phillips et al. 1992, ISO 1999*b*). We defined an activated foothold or foot-encapsulating trap as one having been sprung (i.e., trap jaws or strike bar in closed position) by the focal species, an activated footsnare as one where the cable loop was at least partially closed by the animal, and an activated cage trap as one with the door closed. When a trap was activated without a capture, trappers examined tracks and other evidence at trap stations to identify species. If the trapper could not reasonably identify the species that had activated the trap, we considered the species unknown and we did not use those activations in the calculation of capture efficiency.

Table 2. Description of individual injury scores and associated trauma classes delineated in International Organization for Standardization (1999*b*) protocols and used for assessing trap-related injuries during post-mortem examination of furbearers captured during development of best management practices for trapping in the United States, 1997–2018.

Trauma category observation	Trauma score (points)
No trauma	0
Mild	
Claw loss	2
Oedematous swelling or hemorrhage	5
Minor cutaneous laceration	5
Minor subcutaneous soft-tissue maceration or erosion (contusion)	10
Major cutaneous laceration, except on foot pads or tongue	10
Minor periosteal abrasion	10
Moderate	
Severance of minor tendon or ligament (each occurrence)	25
Amputation of 1 digit	25
Permanent tooth fracture exposing pulp cavity	30
Major subcutaneous soft-tissue maceration or erosion	30
Major laceration on foot pads or tongue	30
Severe joint hemorrhage	30
Joint luxation at or below carpus or tarsus	30
Major periosteal abrasion	30
Simple rib fracture	30
Eye lacerations	30
Minor skeletal muscle degeneration	30
Moderately severe	
Simple fracture at or below carpus or tarsus	50
Compression fracture	50
Comminuted rib fracture	50
Amputation of 2 digits	50
Major skeletal muscle degeneration	55
Limb ischemia	55
Severe	
Amputation of ≥3 digits	100
Any fracture or joint luxation on limb above carpus or tarsus	100
Any amputation above digits	100
Spinal cord injury	100
Severe internal organ damage (internal bleeding)	100
Compound or comminuted fracture at or below carpus or tarsus	100
Severance of major tendon or ligament	100
Compound rib fractures	100
Ocular injury resulting in blindness of an eye	100
Myocardial degeneration	100
Mortality	100

On the assumption that commonly used traps deployed by experienced avocational trappers were providing minimally acceptable efficiency (i.e., they were voluntarily being used), we, in consultation with experienced trappers and national trapping organizations, examined preliminary efficiency data from typical trap lines to establish a BMP threshold. To pass our BMP efficiency criterion, we required that the trap capture and restrain ≥60% of the individuals of the focal species that activated it.

Selectivity.—Selectivity is an important trap performance metric, with a goal of minimizing the number of captures of protected or non-furbearing species. We calculated trap-specific furbearer selectivity by dividing the total number of captures of furbearers that were legal to harvest by the total number of captures of all species (ISO 1999*b*; AFWA 2006). We used furbearer selectivity, as opposed to species-specific selectivity, for 2 reasons. First, our testing effort (e.g., number of projects, geographic locations) for specific traps was asymmetric within and across species, confounding interpretation of species-specific trap selectivity and reducing the value of species-trap model comparisons from our dataset. Second, the intent of trappers, and therefore the goal of many of the BMP field projects, was often to set a particular trap in a manner that facilitates capture of multiple furbearing species that are legal within a given jurisdiction during the regulated harvest season; species-specific selectivity would not have reflected the design of many projects we undertook. Hence, our measure of furbearer selectivity is trap-specific (i.e., not trap × target species-specific), and represents average furbearer selectivity for that trap model under the varying conditions (e.g., variable species diversity, land uses, climate) where it was tested during 1997–2018. The only exception to this is for Arctic foxes, where testing was conducted on an isolated island in which no other furbearers were present; lumping data from this project with other projects where the same trap models had been tested did not seem appropriate, and furbearer selectivity thus equated with Arctic fox selectivity for this species.

Trap Evaluation

We largely use a descriptive approach (Guthery et al. 2001) to report and discuss results for restraining traps based on animal welfare, capture efficiency, and selectivity. For the injury-score and lower-trauma criteria, we graphically present distributional information using box and whisker plots and percent stacked bar charts, respectively. For efficiency and furbearer selectivity metrics, we computed exact binomial confidence intervals following Clopper and Pearson (1934). We collated numeric results for each of the 4 metrics, along with the states, years of testing, and number of trapper-technician teams used for each trap-species combination and the record of injury codes for each trap-species combination (Tables S2–S37, available online in Supporting Information). We identified whether a given model of restraining device met all BMP criteria, and where possible, we compared within-species relative performance of restraining device types tested, and also assessed spatial variability in performance for a given trap-species combination when possible as part of our broader analyses.

Although we required a minimum sample of 20 captures and necropsies (with the exception noted above) for determination of whether a trap passed BMP welfare and efficiency thresholds, for broader comparative value we report data for any trap with a species-specific sample size ≥8 and regardless of whether the trap is commonly used by trappers to target that species. For some species-trap combinations, capture sample size used to estimate efficiency exceeded the number of animals necropsied. This occurred because some animals that could be included as captures for efficiency calculations were either unavailable for post-mortem examination (e.g., killed or scavenged while in trap, damaged or destroyed because of freezer failure prior to necropsy) or were not necropsied for budgetary reasons when captured during field projects in subsequent years after the minimum sample size requirement had already been met.

Because we focused our research design on species-specific trap testing and BMP development, we did not systematically test the same number, types, and sizes of traps on all species. Nonetheless, our collective dataset does allow for broader examination of patterns in trap performance. For instances where we tested a specific trap on the same species in multiple states or regions, and where sample sizes in each met our BMP requirements, we compared average cumulative injury scores using analysis of variance or independent 2-sample *t*-tests, depending on the number of groups. Where applicable, we used informal guidelines (Cumming and Finch 2005) to visually assess differences or patterns in injury scores and trap efficiency across taxonomic groups (we included striped skunks with the mustelids for simplification), broad body-size class assignments based on average species-specific weights from various literature sources (<2.0 kg [small species], 2.0–3.9 kg [medium-small], 4.0–6.9 kg [medium], 7.0–10 kg [medium-large], and >10.0 kg [large]), trap types (cage, foot-encapsulating, foothold, and footsnare), foothold trap jaw types (standard jaw, double jaw, offset or laminated jaw, and padded jaw), and trap sizes. We also examined the association between cumulative injury scores and incidence of self-directed biting using a Pearson correlation coefficient. Because our measure of selectivity was trap-specific, not trap × target species-specific, we focused our broad examination of selectivity data on those variables specific to the trap (i.e., trap type or size). In addition, we summarized selectivity and efficiency results based on whether we tested each trap model in only land sets, only water sets, or both. Our subsequent use of trap size is based largely on the common, albeit not rigorously standardized, nomenclature used by trap manufacturers (e.g., number 1.5, number 1.75). Although this nomenclature is typically associated with trap jaw spreads, it is not an actual measurement in itself. In cases where trap manufacturers used different naming nomenclature (e.g., MB550), we assigned those traps to the more common numbering system based on the typical range of jaw spreads in that trap size class.

RESULTS

We report performance data for 84 models of restraining traps across 19 furbearing species, or 231 trap-species combinations. Restraining devices we tested include 68 models of foothold traps, 9 models of foot-encapsulating devices, 6 models of cage traps, and 1 model of power-activated footsnare (Appendix A). We collected data from 1,970 trapper-technician teams, averaging 8.6 teams per trap-species combination (range = 1–29;

median = 8). We conducted whole body necropsies on 8,566 furbearers collected from trappers during 1997–2018, of which 0.5% of the animals were dead upon trap inspection from what we deemed trap-related stress or injury. For the 231 trap-species combinations, we had sufficient sample size (i.e., $n \geq 20$) to evaluate 173 combinations, of which 59% met all BMP criteria.

American Badger

Trappers captured 171 badgers (*Taxidea taxus*) in 9 different models of restraining devices, all foothold traps, in the Great Plains-West and Midwest regions; we conducted post-mortem examinations on 166. All foothold traps met BMP criteria for animal welfare and capture efficiency, but the sample sizes for 3 traps are currently insufficient for BMP inclusion (Fig. 5; Table S3). For devices that met sample size requirements, capture efficiency for each was >95% and furbearer selectivity was >89% (Fig. 5; Table S3). Post-mortem examination of captured badgers showed that >78% of animals in those trap models sustained injuries in the lower-trauma categories (Fig. 5). The most common injuries were mild edema, minor cutaneous laceration, and minor (superficial) soft tissue maceration; <4% of captured badgers showed evidence of self-directed biting and no mortalities occurred from trap-related stress or injury (Tables S1 and S4). Six restraining devices tested on badgers met all BMP criteria (Fig. 5; Table S3).

American Beaver

Trappers captured 144 beavers in 3 different models of restraining traps (2 models of cage trap [HAN, BTH], 1 model of foothold trap [MB750]; see Appendix A for trap code definitions) in the Midwest, Northeast, and Southeast regions; we conducted post-mortem examinations on 137. Cumulative injury scores for both cage traps met the injury-score criterion, whereas the MB750 failed this criterion (Fig. 6; Table S5). Greater than 97% of the animals sustained either no or mild injuries in cage traps, whereas 65% of beavers captured in the MB750 foothold trap sustained a severe injury (Fig. 6). Mild edema and minor periosteal abrasion were common in all traps, with additional common injuries in the foothold trap being minor and major cutaneous laceration, minor and major

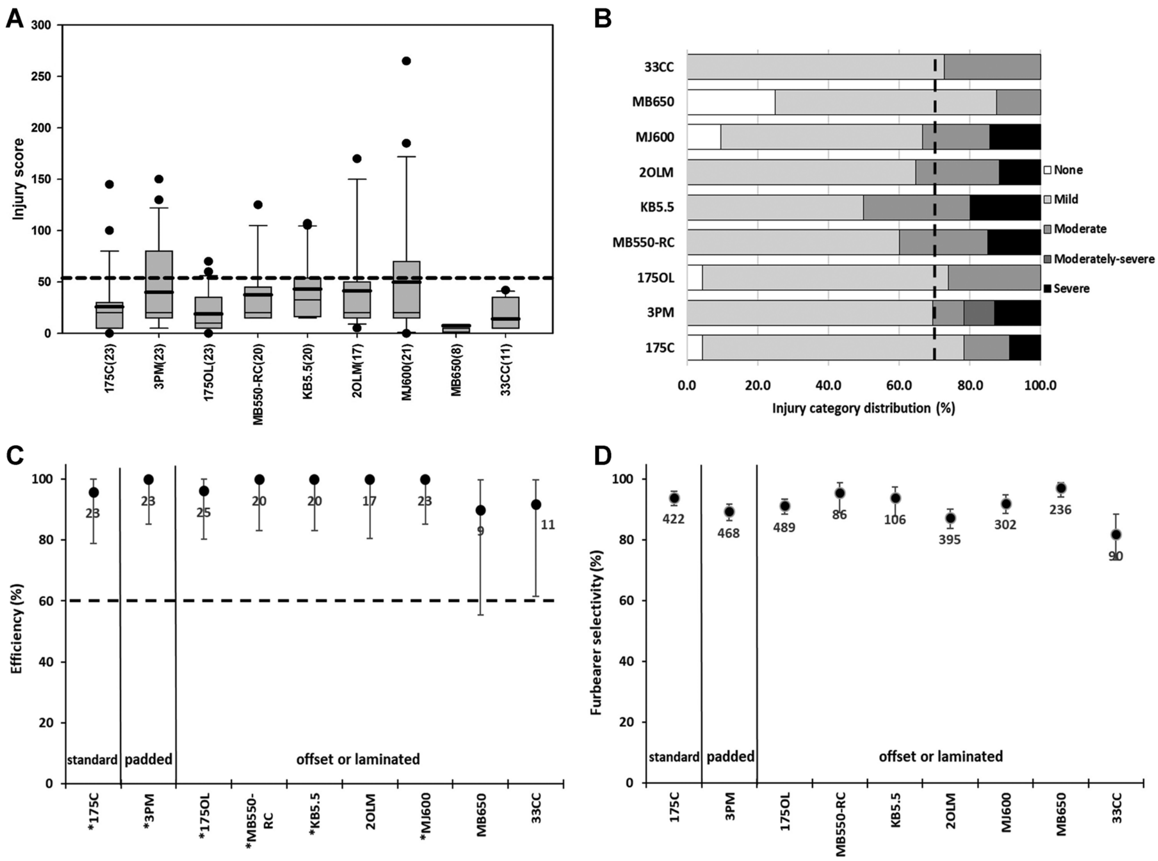

Figure 5. Trap performance profiles for live-restraining traps evaluated on American badgers from 1997–2018 during development of best management practices (BMPs) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of badgers captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of badgers captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

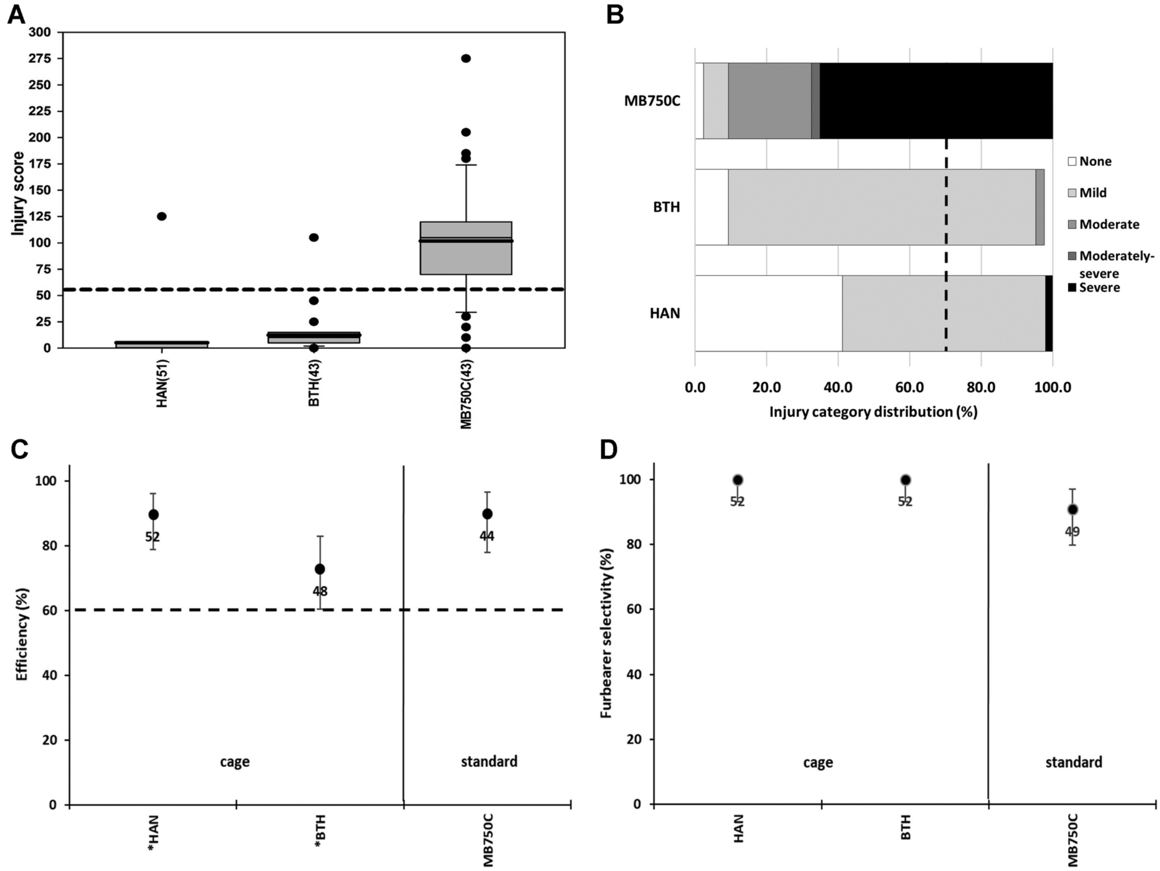

Figure 6. Trap performance profiles for live-restraining traps evaluated on American beavers from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of beavers captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of beavers captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

subcutaneous soft tissue maceration, and fracture or joint luxation above the carpus or tarsus (Tables S1 and S6). One of 138 beavers had evidence of self-directed biting, and 1 beaver (in the BTH) died from trap-related stress or injury (Tables S1 and S6). Efficiency in the BTH trap was lower than for the other 2 traps (73% vs. 90%), and furbearer selectivity was ≥90% for all 3 devices (Fig. 6; Table S5). Two of the 3 restraining devices (both cage traps) tested on beavers met all BMP criteria (Fig. 6; Table S5).

Arctic Fox

We captured 64 Arctic foxes in Alaska using 2 models of padded-jaw foothold traps (1P, 15P) and 1 model of cage trap (Cage 207; Appendix A). We released 2 foxes (per other permit requirements) unharmed and conducted post-mortem examinations on 62 foxes. All 3 trap models had a mean cumulative injury score <10.0 and all injuries were in the lower-trauma categories (Fig. 7; Table S7). The most common injury from each trap model was mild edema or hemorrhage; 2 foxes captured in the cage trap had chipped or fractured teeth (Tables S1 and S8). There was no evidence of self-directed biting and no Arctic foxes died because of trap-related stress or injury (Tables S1 and S8). Capture efficiency did not significantly vary across trap models, with all traps ≥92% efficient. Species selectivity was 100% for all 3 trap models evaluated on Arctic foxes (Fig. 7; Table S7), and all 3 models we evaluated met all BMP criteria (Fig. 7; Table S7).

Bobcat

Trappers captured 537 bobcats in 14 different models of foothold traps (13 coil-spring, 1 double longspring), 1 model of footsnare, and 1 model of cage trap in the Great Plains-West, Midwest, Northeast, and Southeast regions (Fig. 8; Table S9); we necropsied 502 bobcats. In foothold traps, trappers captured 488 bobcats, of which we conducted post-mortem examinations on 462. Mean cumulative injury scores for bobcats captured in foothold traps averaged 18.5 and ranged from 9.4 to 37.7 (Fig. 8; Table S9) across models, and an average of >96% of injuries were in the lower-trauma categories (Fig. 8). All foothold traps we evaluated met both animal welfare criteria (Fig. 8; Table S9). The number 1.5

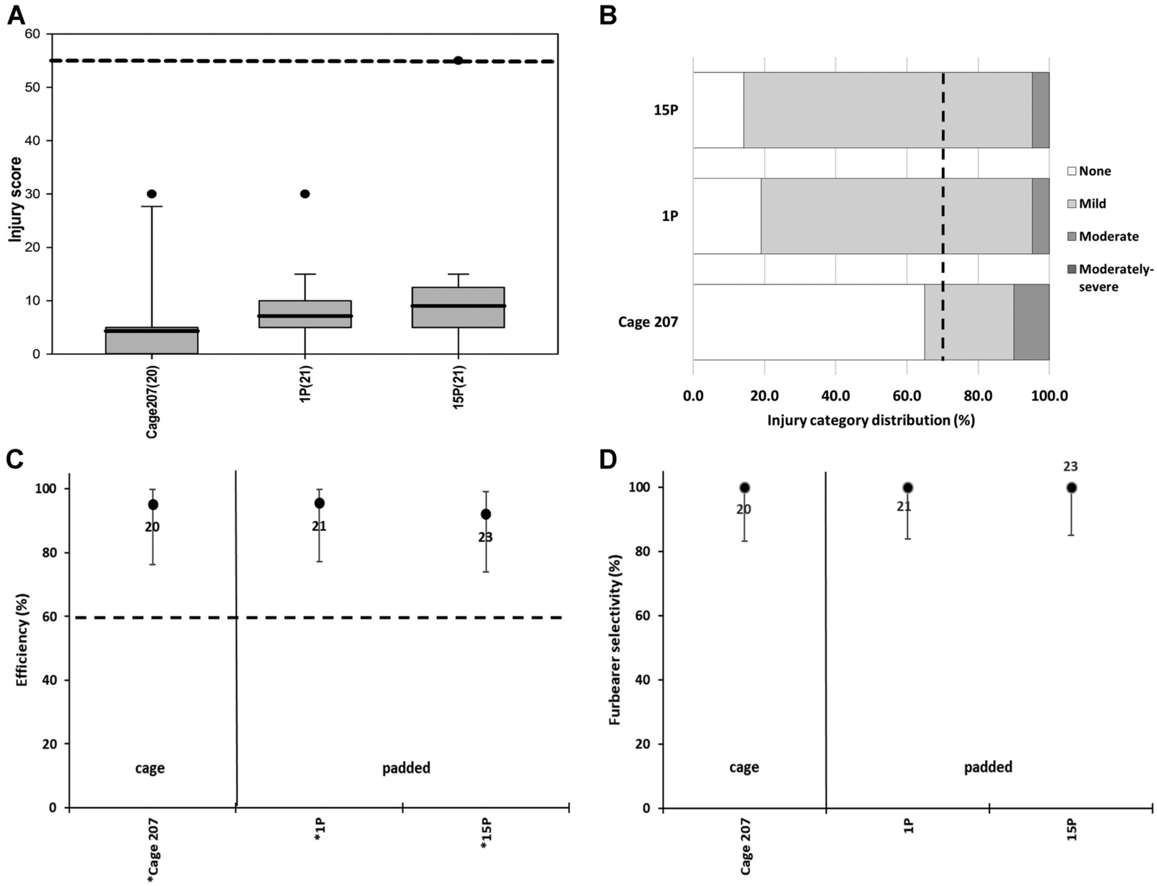

Figure 7. Trap performance profiles for live-restraining traps evaluated on Arctic foxes from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of Arctic foxes captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of Arctic foxes captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

coil-spring trap (15C) had the lowest mean cumulative injury score (9.4), followed closely by the 1.75 coil-spring (175C; 9.8), and the number 3 coil-spring trap with padded jaws and 4 coil-springs (3PM, 10.1; Appendix A). The most common injuries in foothold traps were mild edema and minor cutaneous lacerations. Though moderately severe and severe injuries were uncommon (Fig. 8; Table S9), there was a positive association between trap size and injury scores for standard-jaw foothold traps only; no similar pattern was apparent with padded or offset-laminated-jaw footholds (Fig. 8). Capture efficiency for all foothold traps averaged 89%, and was >77% for all traps; there was a weak positive relationship between trap size and efficiency for all foothold jaw types (Fig. 8). Furbearer selectivity was >85% for all foothold traps, and >90% for 9 of the 13 foothold models, with no obvious effect of trap size on furbearer selectivity (Fig. 8).

Trappers captured 22 bobcats in the wire-mesh cage trap (Cage 109.5; Appendix A). The cage trap had the lowest mean cumulative injury score (<1.0 point) of all traps tested on bobcats (Fig. 8; Table S9). Most bobcats (>95%) captured in the cage trap sustained no injuries (Fig. 8), with 1 individual sustaining mild injuries including claw loss and mild edema (Tables S1 and S10). The cage trap had the highest capture efficiency (100%) but the lowest furbearer selectively (84%) for all traps tested on bobcats (Fig. 8; Table S9).

Trappers captured 27 bobcats in the power-activated footsnare (BEL; Appendix A) and we conducted post-mortem examinations on 18. The mean injury score was 17.3, near the average for all 16 trap models tested (Fig. 8; Table S9). Most injuries (>94%) sustained by bobcats captured in this device were lower-trauma category injuries; the most common injury was mild edema (Fig. 8; Tables S1 and S10). Although necropsy sample size was only 18 in the BEL, if 2 additional bobcats were captured, each would need to have an injury score of 394 for the trap to fail; we deemed this highly improbable (maximum injury score was 90 on the 18 necropsied animals) and concluded the trap met BMP welfare criteria. The BEL had the lowest, but still passing, capture efficiency (75%), and the fourth-lowest furbearer selectivity (88%) of all traps tested on bobcats (Fig. 8; Table S9).

For these 16 trap models evaluated on bobcats, there was no evidence of self-directed biting and we did not find any animals

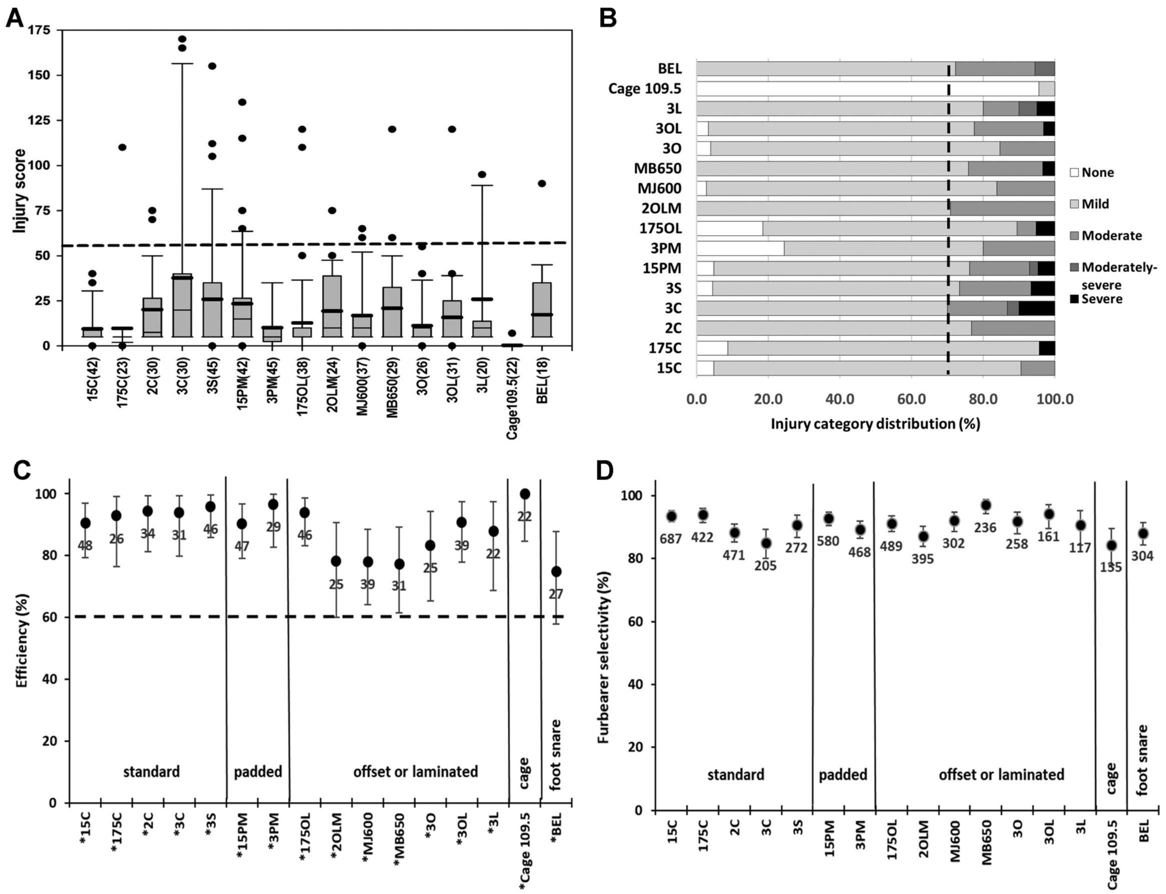

Figure 8. Trap performance profiles for live-restraining traps evaluated on bobcats from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of bobcats captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of bobcats captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

dead because of trap-related stress or injury (Tables S1 and S10). All 16 restraining devices tested on bobcats met all BMP criteria (Fig. 8; Table S9).

Canada Lynx

We tested 2 devices on Canada lynx, the number 3 coil-spring trap with standard jaws (3C) and a power-activated footsnare (BEL; Appendix A). Trappers captured 35 Canada lynx in Alaska, of which we conducted post-mortem examinations on 34 (Fig. 9; Table S11). The 3C met all BMP criteria for animal welfare (mean injury score = 30.2, 87.5% of animals in lower-trauma categories) and capture efficiency (100%). Trappers captured too few lynxes to assess whether the BEL met animal welfare and efficiency criteria.

Roughly two-thirds of individuals captured in the 3C sustained either no or mild injuries (Fig. 9). The most common injuries were lower-trauma category injuries (mild edema or minor hemorrhage, minor cutaneous laceration, and minor subcutaneous soft tissue maceration or erosion; Tables S1 and S12). However, 3 (12.5%) of the 24 lynx captured in the 3C experienced a fracture to the limb, 1 with a simple fracture at or below the carpus or tarsus and 2 with a fracture above this area. None of the lynx had evidence of self-directed biting or were found dead from trap-related stress or injury in the 3C (Tables S1 and S12).

Most (80%) injuries sustained by the 10 lynx captured in the BEL were mild (Fig. 9), primarily mild edema or minor hemorrhage; one lynx had a simple fracture at or below the carpus or tarsus and 1 lynx had a fracture above this area (Tables S1 and S12). None of the captured lynx had evidence of self-directed biting and we did not find any dead because of trap-related stress or injury in the footsnare. The 3C was more efficient but slightly less selective than the BEL (Fig. 9; Table S11). Overall, only the 3C had a sufficient sample size for full evaluation and it met all BMP criteria (Fig. 9; Table S11).

Coyote

Trappers captured 1,546 coyotes in 30 models of foothold traps (29 coil-springs, 1 double-longspring) and 1 model of

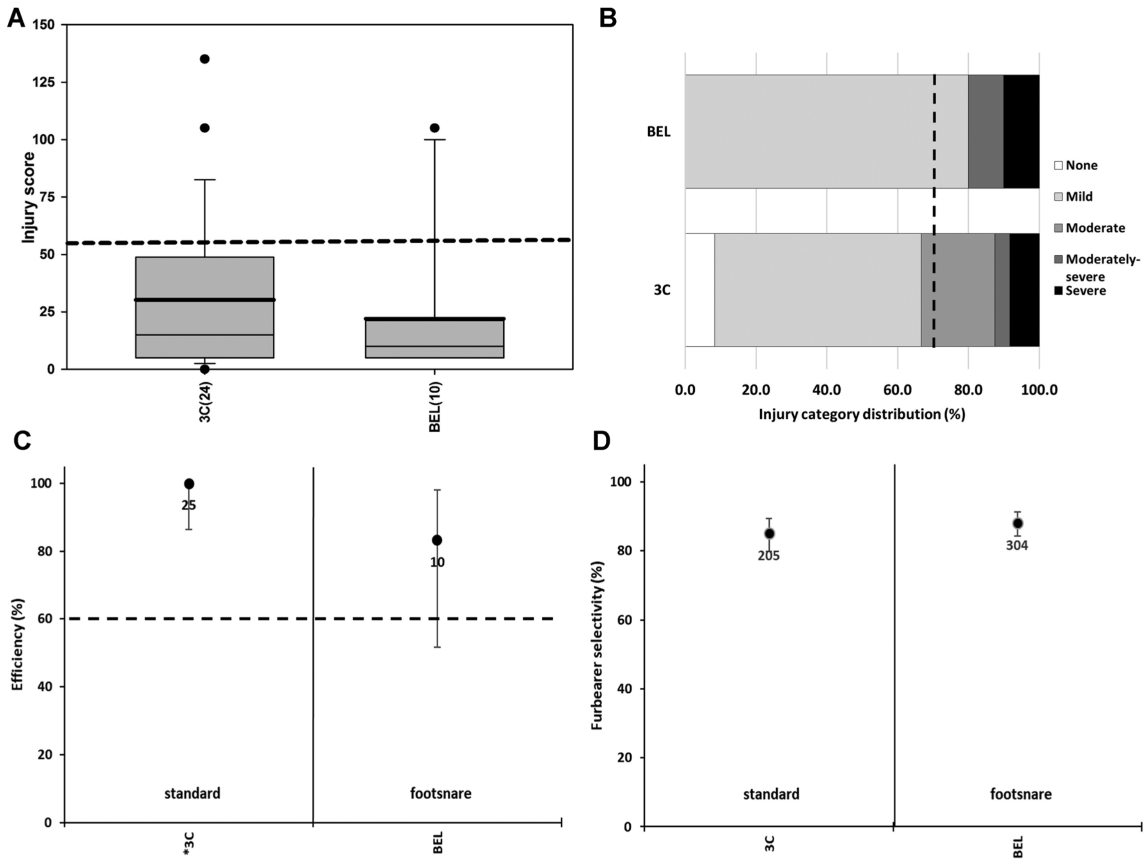

Figure 9. Trap performance profiles for live-restraining traps evaluated on Canada lynx from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of Canada lynx captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of Canada lynx captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

power-activated footsnare in the Great Plains-West, Midwest, Northeast, and Southeast regions. We conducted post-mortem examinations on 1,161 coyotes.

For the 22 foothold traps meeting sample size requirements, mean cumulative injury scores averaged 44.6 and ranged from 16.2 to 98.2 (Fig. 10; Table S13). The mean cumulative injury score for all padded-jaw models meeting sample size requirements (29.1 points) was lower than for offset wide- or cast-jaw models (45.2), offset and laminated models (45.4), standard models (49.4), and the 1 offset only model (98.2). Within both standard and offset- or laminated-jaw types, mean injury scores generally increased with trap size; we did not observe a similar pattern in padded-jaw models (Fig. 10). For foothold traps meeting sample size requirements, 83–100% of injuries were in the lower-trauma categories (Fig. 10; Table S13). The most common injuries among all foothold trap types were mild edema, minor lacerations, and minor periosteal abrasions (Tables S1 and S14). For foothold traps with sufficient sample size, 20 of 22 passed BMP animal welfare criteria (Fig. 10; Table S13).

Capture efficiency for foothold traps meeting sample size requirements ranged from 56–100%, and averaged 85.1%; the number 1.5 padded with 2 coil-springs (15P; Appendix A) failed the BMP efficiency criterion. For traps with adequate sample size, average efficiency scores by jaw type were offset only (92.8%; 1 model), offset and laminated (87.7%), offset wide or cast (85.9%), standard (82.6%), and padded (81.1%). Efficiency generally increased with trap size for padded- and standard-jaw models, but not for offset- or wide-laminated-jaw models (Fig. 10; Table S13). For all foothold traps meeting sample size requirements, furbearer selectivity was >81%, and ≥90% for 16 of 24 traps (Fig. 10; Table S13).

Trappers captured 73 coyotes in the footsnare (BEL; Appendix A) and we conducted post-mortem examinations on 49. Ninety-six percent of coyotes sustained only lower-trauma injuries (Fig. 10). The most common injuries recorded were mild edema and minor lacerations (Tables S1 and S14). This restraining device met all criteria for animal welfare (mean injury score = 22.7, 95.9% of animals in lower-trauma categories) and capture efficiency (74.5%), and furbearer selectivity in the BEL (88.1%) was slightly above the average for all foothold traps (Fig. 10; Table S13).

For all restraining traps meeting sample size requirements, self-directed biting occurred in an average of 2.2% of coyotes (median = 0%), and we did not find any coyotes dead because of

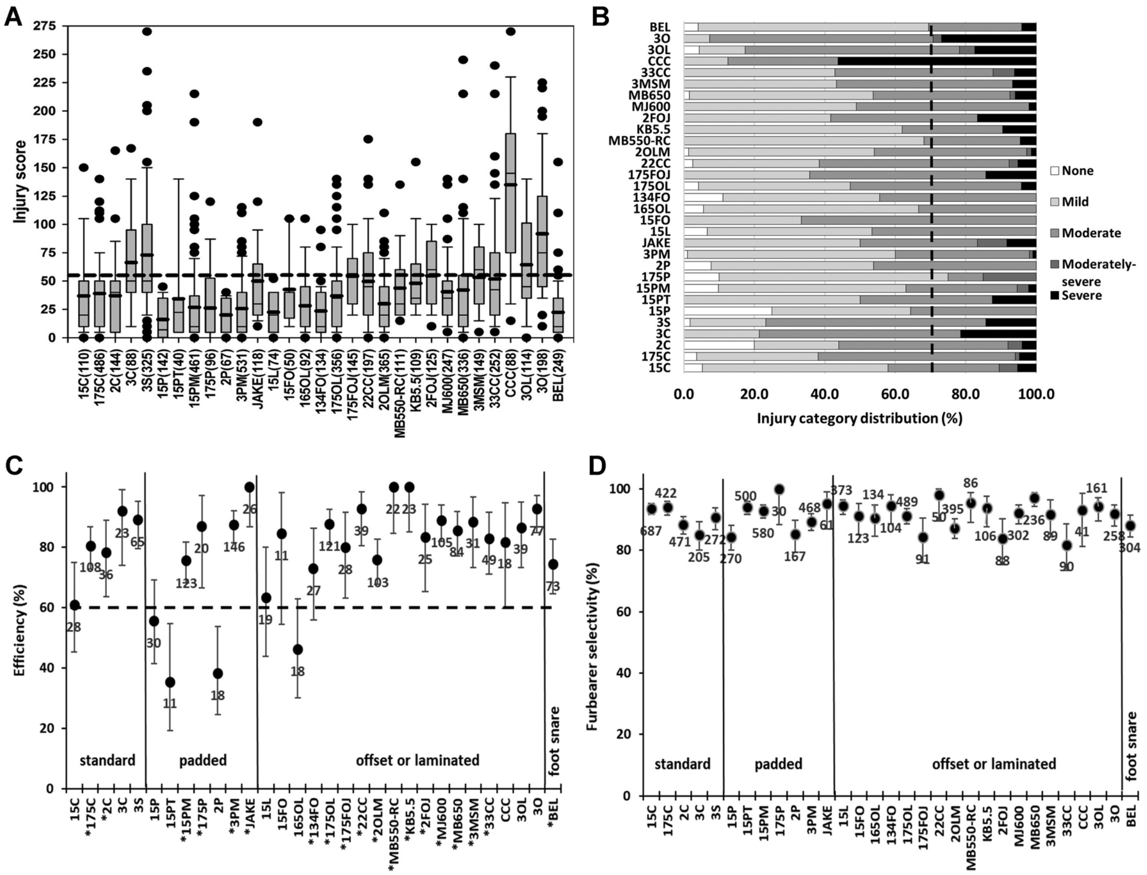

Figure 10. Trap performance profiles for live-restraining traps evaluated on coyotes from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of coyotes captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of coyotes captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

trap-related stress or injury (Tables S1 and S14). Nineteen restraining devices met all BMP criteria, 3 failed the animal welfare criteria, 1 failed the efficiency criterion, and 8 currently have insufficient sample sizes to reach a conclusion (Fig. 10; Table S13).

Fisher

Trappers captured 79 fishers, of which we conducted post-mortem examinations on 74, in the Midwest and Northeast regions using 4 restraining devices (the number 1.5 coil-spring foothold trap with standard jaws [15C], the number 1.5 coil-spring foothold trap with padded jaws and 4 coil-springs [15PM], the number 1.75 coil-spring foothold trap with offset and laminated jaws [175OL], and a wire-mesh cage trap [Cage 108]; Appendix A). All animal welfare and capture efficiency criteria were met for both the 15PM and the Cage 108 (Fig. 11; Table S15). The sample size for the 15C ($n = 19$) was less than required, though the trap could not pass BMP welfare criteria even if 1 additional animal had no injuries. The sample size for the number 175OL ($n = 13$) was insufficient to evaluate against BMP welfare criteria.

Of the 54 fishers captured in foothold traps and necropsied, the most common injuries were mild edema, minor hemorrhage, minor lacerations, minor periosteal abrasion, and minor subcutaneous soft tissue maceration (Tables S1 and S16). We found evidence of self-directed biting on 1 fisher, and we did not find any fishers dead from trap-related stress or injury (Tables S1 and S16).

For the 20 fishers captured in the Cage 108, the mean injury score was 5.0; 80% sustained no injury (Fig. 11; Table S15) and the most common (15% of fishers) injury was chipped or fractured teeth. We did not find any evidence of self-directed biting or any fishers dead from trap-related stress or injury in the cage trap (Tables S1 and S16).

Capture efficiency for all restraining traps evaluated on fishers was >82%, and furbearer selectivity was >91% for the 3 foothold traps and 88% for the cage trap (Fig. 11; Table S15). Overall, 2 restraining devices tested on fishers met all BMP criteria, 1 device failed welfare criteria, and 1 had insufficient sample size to confirm (Fig. 11; Table S15).

Gray Fox

Trappers captured 938 gray foxes (*Urocyon cinereoargenteus*) in 22 models of foothold traps (all coil-spring traps), 1 model of

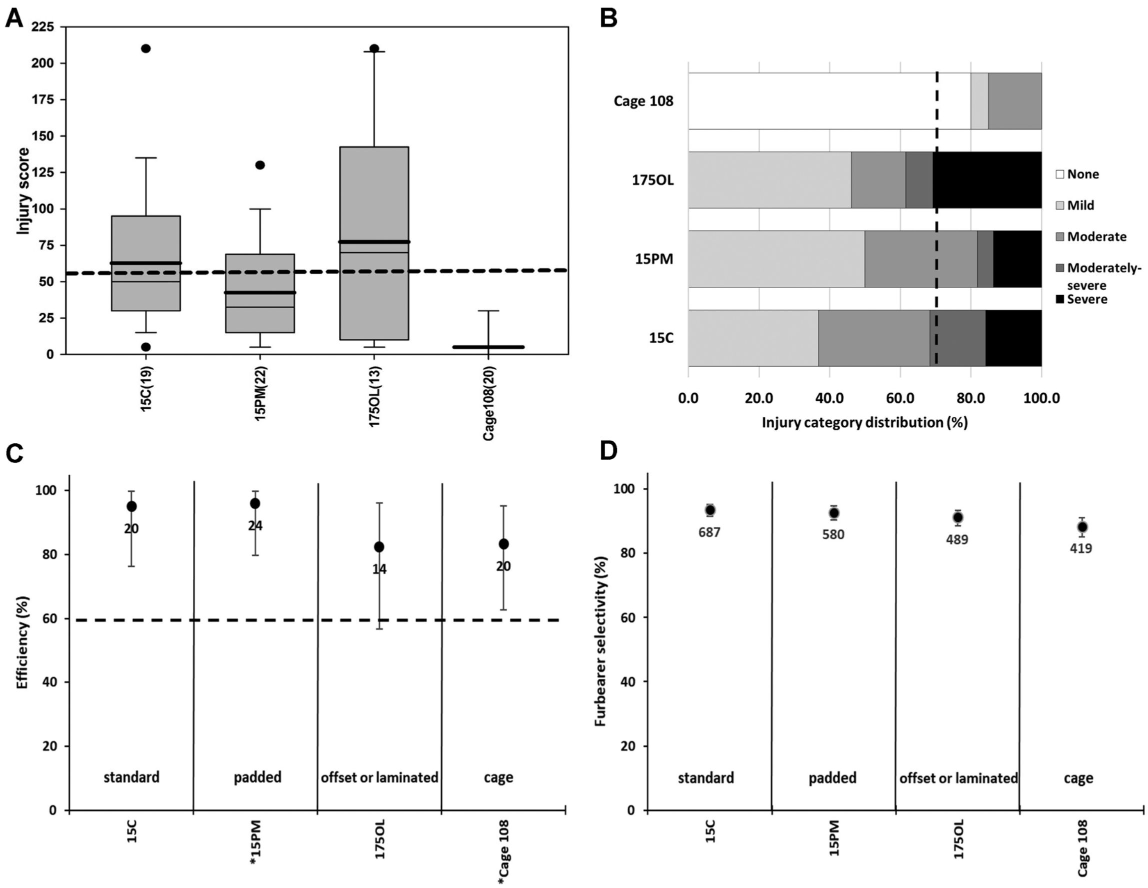

Figure 11. Trap performance profiles for live-restraining traps evaluated on fishers from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of fishers captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of fishers captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

power-activated footsnare (BEL), and 1 model of wire-mesh cage trap (Cage 108; Appendix A) in the Great Plains-West, Midwest, Northeast, and Southeast regions. We conducted post-mortem examinations on 748 gray foxes.

Of foothold traps with sufficient sample size, 8 models (5 padded-jaw models and 3 offset, wide, or laminated models) passed both welfare criteria (Fig. 12; Table S17). Five additional models failed both welfare criteria (1 double-jaw, 1 padded-jaw, and 3 offset- or laminated-jaw models), and 5 passed the lower-trauma criterion but failed the injury-score criterion (1 standard jaw, 1 padded jaw, and 3 offset- or laminated-jaw models). There was a positive correlation between injury scores and trap size for padded-jaw models only. Overall, the most common injuries were mild edema, minor cutaneous lacerations, and chipped or fractured teeth; we observed evidence of self-directed biting in 33 (4%) gray foxes, and found 5 (<1%) individuals dead because of trap-related stress or injury in foothold traps (Tables S1 and S18). Of the 8 foothold traps that met both animal welfare criteria, all of them met BMP capture efficiency standards; there was no correlation between efficiency and trap size for any jaw types (Fig. 12; Table S17). The lowest furbearer selectivity among the 8 passing foothold traps was 83% (Fig. 12; Table S17).

Using the footsnare (BEL; Appendix A), trappers captured 23 gray foxes, of which we necropsied 22. The mean injury score was 51.1 and 82% of gray foxes sustained only lower-trauma injuries (Fig. 12; Table S17). The most common injuries were mild edema and minor lacerations; we detected self-directed biting in 1 (5%) gray fox and did not find any dead from trap-related stress or injury in the BEL (Tables S1 and S18). We excluded 1 trapper's efficiency data because they had highly atypical gray fox footsnare efficiency results (7% vs. >80% for other trappers); revised gray fox capture efficiency in the BEL was 84%, slightly below the average for foothold traps (86%; Fig. 12; Table S17), and furbearer selectivity for this device was 88%.

Most (95%) gray foxes captured in the Cage 108 sustained only lower-trauma injuries, and the mean injury score was 29.7 (Fig. 12; Table S17). The most common injuries were chipped or fractured teeth; we did not detect any self-directed

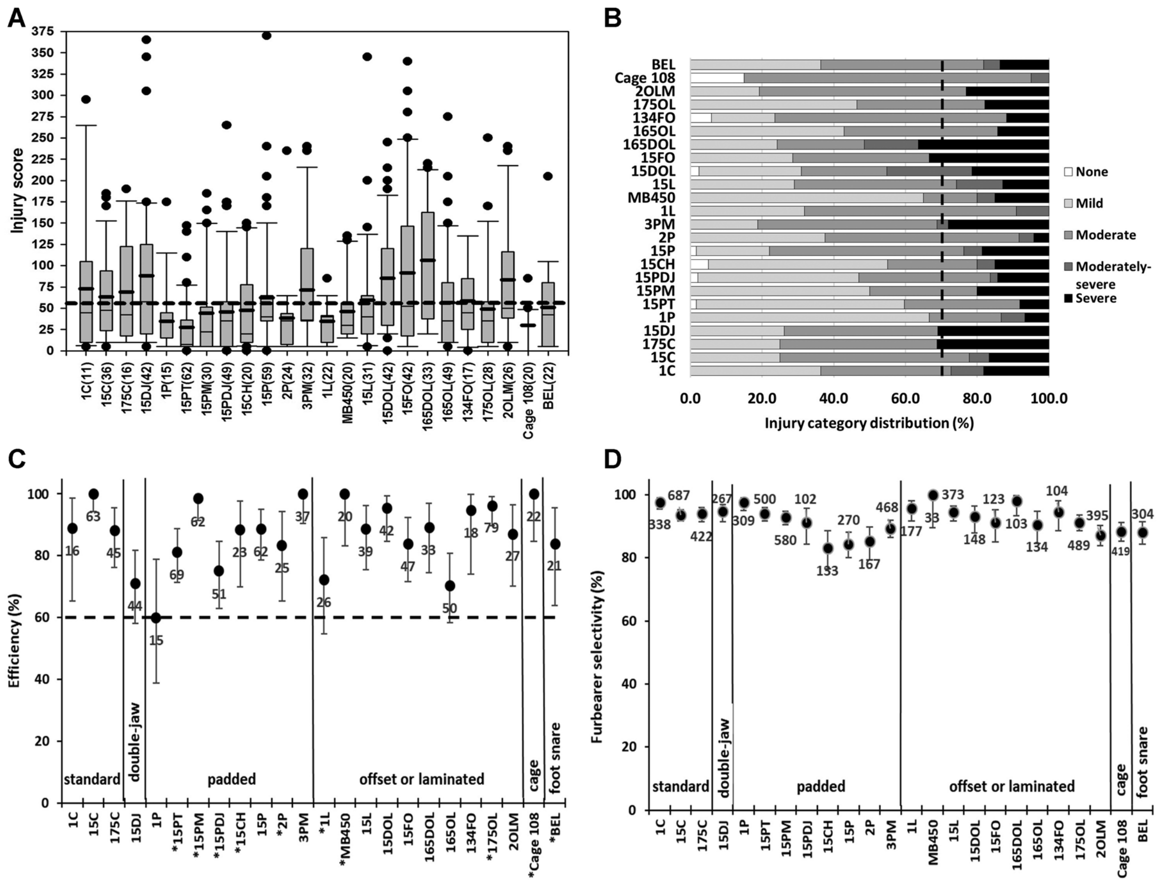

Figure 12. Trap performance profiles for live-restraining traps evaluated on gray foxes from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of gray foxes captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of gray foxes captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

biting and did not find any gray foxes dead because of trap-related stress or injury in cage traps (Tables S1 and S18). The Cage 108, along with 3 foothold traps, had the highest capture efficiency (100%), and furbearer selectivity was 88% (Fig. 12; Table S17). The Cage 108 met all animal welfare and efficiency criteria. Overall, 10 restraining devices evaluated on gray foxes met all BMP criteria, 10 failed one or both welfare criterion, and 4 had insufficient sample size to confirm (Fig. 12; Table S17).

Gray Wolf

Trappers captured 123 gray wolves in 5 models of foothold traps, which included 2 different anchoring systems (stakes vs. grapples), in the Midwest region. We conducted post-mortem examinations on all captured wolves.

Four models had sufficient data for BMP evaluation of animal welfare (Fig. 13; Table S19); all 4 models met both the injury-score (max. = 54.3 points) and lower-trauma criteria (each with >89% of injuries in the lower-trauma categories; Fig. 13; Table S19). The most common injuries for all foothold traps were mild edema or hemorrhage, minor subcutaneous soft tissue maceration or erosion, and minor (superficial) periosteal abrasion; 2 (1.6%) had evidence of self-directed biting, and we did not find any wolves dead from trap-related stress or injury (Tables S1 and S20). There was no consistent difference in injury or efficiency scores between the 2 trap-anchoring methods. Each anchoring method for the Livestock Protection Company number 4 trap had higher capture efficiency than the similar anchoring method for the Minnesota Brand MB750 trap (i.e., LPC4G vs. MB750G, LPC4K vs. MB750K; Appendix A), but all 4 traps met the efficiency criterion; among all traps, the lowest capture efficiency was 81% (Fig. 13; Table S19). All 4 foothold trap models with sufficient sample size met all BMP criteria (Fig. 13; Table S19), and another model (MB650; Appendix A) is likely to pass pending additional sampling. Furbearer selectivity in all devices was ≥93%.

Muskrat

Trappers captured 113 muskrats, many incidental on projects for other species, in 9 different models of foothold traps and

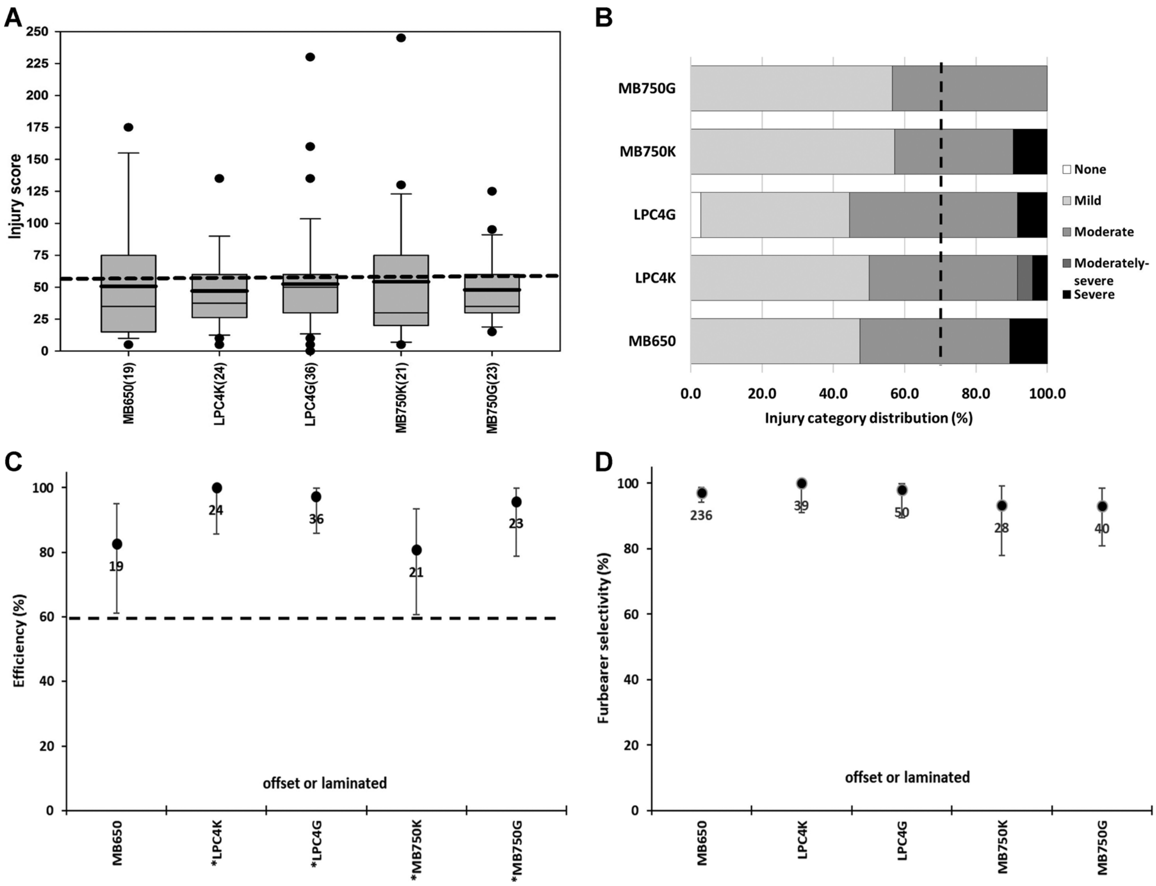

Figure 13. Trap performance profiles for live-restraining traps evaluated on gray wolves from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of gray wolves captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of gray wolves captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

1 model of wire-mesh cage trap (Cage 105.5; Appendix A) in the Midwest region. We conducted post-mortem examinations on 88 muskrats. For other species, we limited our reporting to traps with a minimum sample size of 8; however for muskrats we include 1 device (number 1 longspring with an immobilization guard [1VG]; Appendix A) with a sample size of 5 because of its unique design. However, sample sizes for all but 1 foothold trap (the number 11 double-longspring trap with padded jaws [11P]; Appendix A) were too low for BMP assessment. Although we could have collected additional samples, we chose not to because injury scores were not promising and few, if any, biologists or trappers intentionally live restrain muskrats using foothold traps.

Using the 11P, trappers captured 20 muskrats; this trap failed both welfare criteria (Fig. 14; Table S21). The most common muskrat injuries from this model of foothold trap, similar to other foothold traps, were mild edema or hemorrhage and fracture or joint luxation above the carpus or tarsus; no muskrats showed evidence of self-directed biting and we did not find any dead from trap-related stress or injury in this trap model (Tables S1 and S22). The 11P met the capture efficiency criterion, and furbearer selectivity for this device was 89% (Fig. 14; Table S21). Although sample size is quite low, results from testing of the number 1VG, designed to reduce injury in muskrats, indicate that the trap does reduce injury in comparison to other foothold models (Fig. 14; Table S21), though perhaps not enough to meet BMP welfare criteria for live-restraining traps.

Trappers captured 24 muskrats in the Cage 105.5, which met all BMP welfare (mean injury score = 6.0, 95.8% of animals in lower-trauma categories) and efficiency criteria (100%; Fig. 14; Table S21). Most (>62%) captured muskrats sustained no injuries, and 1 sustained a moderately severe injury (Fig. 14; Table S22). The most common injuries noted were mild edema or minor hemorrhage ($n = 7$) and recently chipped or fractured teeth ($n = 3$); no self-directed biting occurred and we did not find any muskrats dead from trap-related stress or injury in the cage trap (Tables S1 and S22). The Cage 105.5 was 96% efficient on muskrats, and furbearer selectivity in this device was 96% (Fig. 14; Table S21). Overall, of the 2 devices with

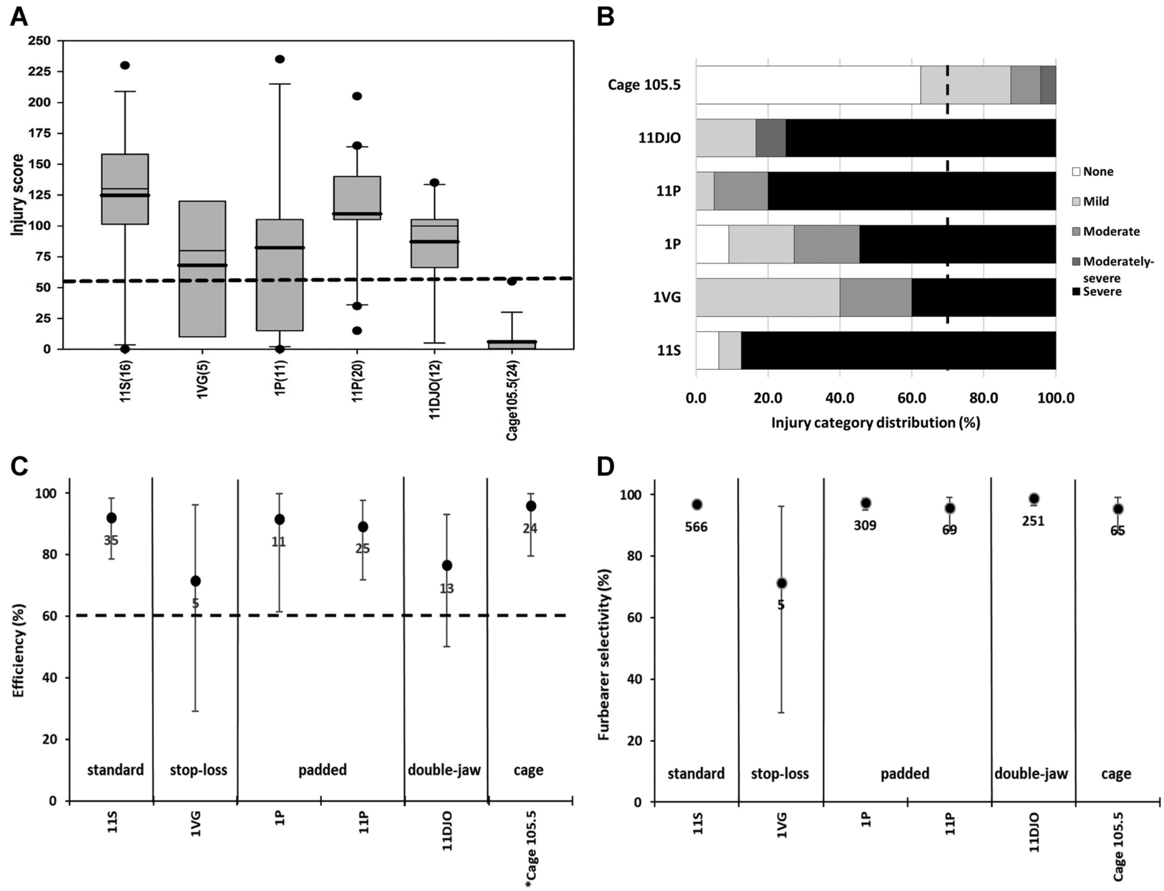

Figure 14. Trap performance profiles for live-restraining traps evaluated on muskrats from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of muskrats captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of muskrats captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

sufficient data, only the cage trap met all BMP criteria for use as a live-restraining device on muskrats (Fig. 14; Table S21).

North American River Otter

Trappers captured 76 river otters, of which we necropsied 70, in 3 different models of foothold traps (number 11 double-longspring with standard [11S] and double jaws [11DJ] and the number 2 coil-spring with standard jaws [2C]; Appendix A) in the Midwest and Southeast regions. For all traps, mean cumulative injury scores were ≤49 points and most otters (≥81%) sustained injuries in only the lower-trauma categories (Fig. 15; Table S23). The most common injuries were mild edema, minor subcutaneous soft tissue maceration, and minor lacerations; 6 (9%) otters exhibited chipped or fractured teeth, nearly all (5) in the 2C. Self-directed biting occurred on 1 occasion in the 11S and 11DJ, and on 3 occasions in the 2C (Tables S1 and S24). We did not find any otters dead because of trap-related stress or injury (Tables S1 and S24). All 3 foothold traps met both animal welfare criteria; however, all 3 failed the BMP efficiency criterion (Fig. 15; Table S23). Furbearer selectivity for all 3 traps was >88%.

Northern Raccoon

We obtained raccoon data for 50 restraining trap models, of which 40 had sample sizes ≥20 (8 standard-jaw foothold models, 11 double-jaw foothold models, 6 padded-jaw foothold models, 4 offset, laminated, or wide-jaw foothold models, 9 foot-encapsulating traps, 1 cage trap, and 1 footsnare) in the Great Plains-West, Midwest, Northeast, and Southeast regions. Trappers captured 4,078 raccoons, of which we conducted post-mortem examinations on 2,919 (Fig. 16; Table S25).

Foothold traps.—Of 1,141 raccoons captured in 8 models of standard-jaw coil-spring traps meeting sample size requirements, we conducted post-mortem examinations on 733. No standard-jaw foothold models passed the injury-score criterion and only 1 passed the lower-trauma criterion (Fig. 16; Table S25). The mean cumulative injury score for all standard-jaw foothold models meeting sample size requirements was 82.6. Although

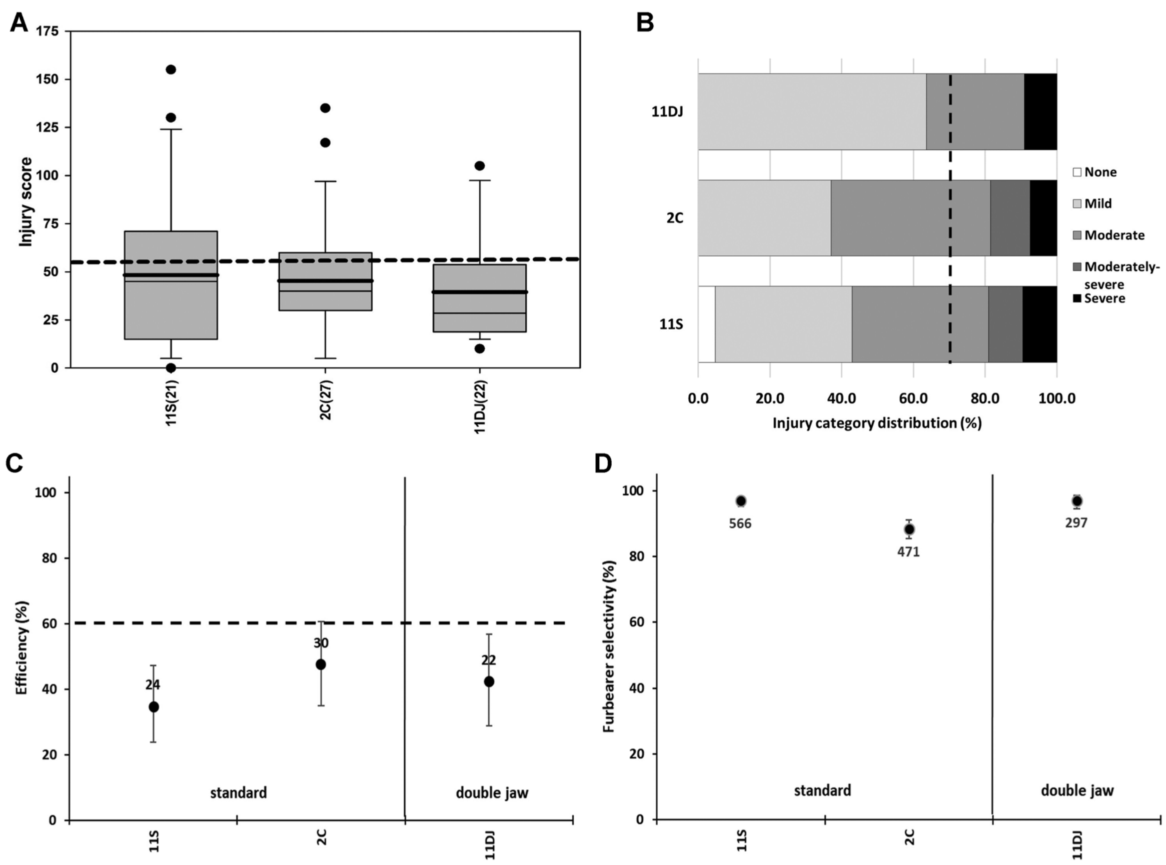

Figure 15. Trap performance profiles for live-restraining traps evaluated on North American river otters from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of North American river otters captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of North American river otters captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

the most common injuries in standard-jaw foothold traps were in the mild category, particularly swelling, minor laceration, minor tissue maceration, and minor periosteal abrasion, 40% of animals captured in standard-jaw footholds sustained severe injuries and 30% of animals exhibited self-directed biting (Tables S1 and S26). We found 1 raccoon dead from trap-related stress or injury in a standard-jaw foothold. There was no clear association between trap size and injury score for standard-jaw footholds (Fig. 16; Table S25). All standard-jaw foothold models with adequate sample size passed the BMP efficiency criterion (range = 71–94%), and efficiency generally increased with trap size (Fig. 16; Table S25). Furbearer selectivity ranged from 94–100% (Fig. 16; Table S25). No standard-jaw footholds tested on raccoons passed all BMP criteria (Fig. 16; Table S25).

Of 910 raccoons captured in 11 models of double-jaw coil-spring traps with adequate sample size, we conducted post-mortem examinations on 697. Four models of double-jaw footholds passed both the injury-score and lower-trauma criteria (Fig. 16; Table S25). The mean cumulative injury score for all double-jaw foothold models with adequate sample size was 67.9. As with standard-jaw models, the most common injuries in double-jaw foothold traps were in the mild category, particularly swelling, minor laceration, minor tissue maceration, and minor periosteal abrasion, but 26% of animals sustained severe injuries and 19% exhibited self-directed biting in double-jaw models (Tables S1 and S26). We found 15 raccoons dead from trap-related stress or injury in double-jaw footholds. There was minimal variation in trap size across double-jaw models tested on which to ascertain any correlation with injury scores or efficiency. All double-jaw foothold models meeting sample size requirements passed the efficiency criterion (range = 70–91%) and furbearer selectivity ranged from 93–100% (Fig. 16; Table S25). Four double-jaw foothold models tested on raccoons passed all BMP criteria (Fig. 16; Table S25).

Of 565 raccoons captured in 6 models of padded-jaw coil-spring traps meeting sample size requirements, we conducted post-mortem examinations on 423. Two models of padded-jaw footholds passed both injury criteria (Fig. 16; Table S25). The mean cumulative injury score for all padded-jaw foothold models meeting sample size requirements was 65.3, similar to double-jaw traps. The most common injuries in padded-jaw foothold traps were in the mild category, particularly swelling and minor

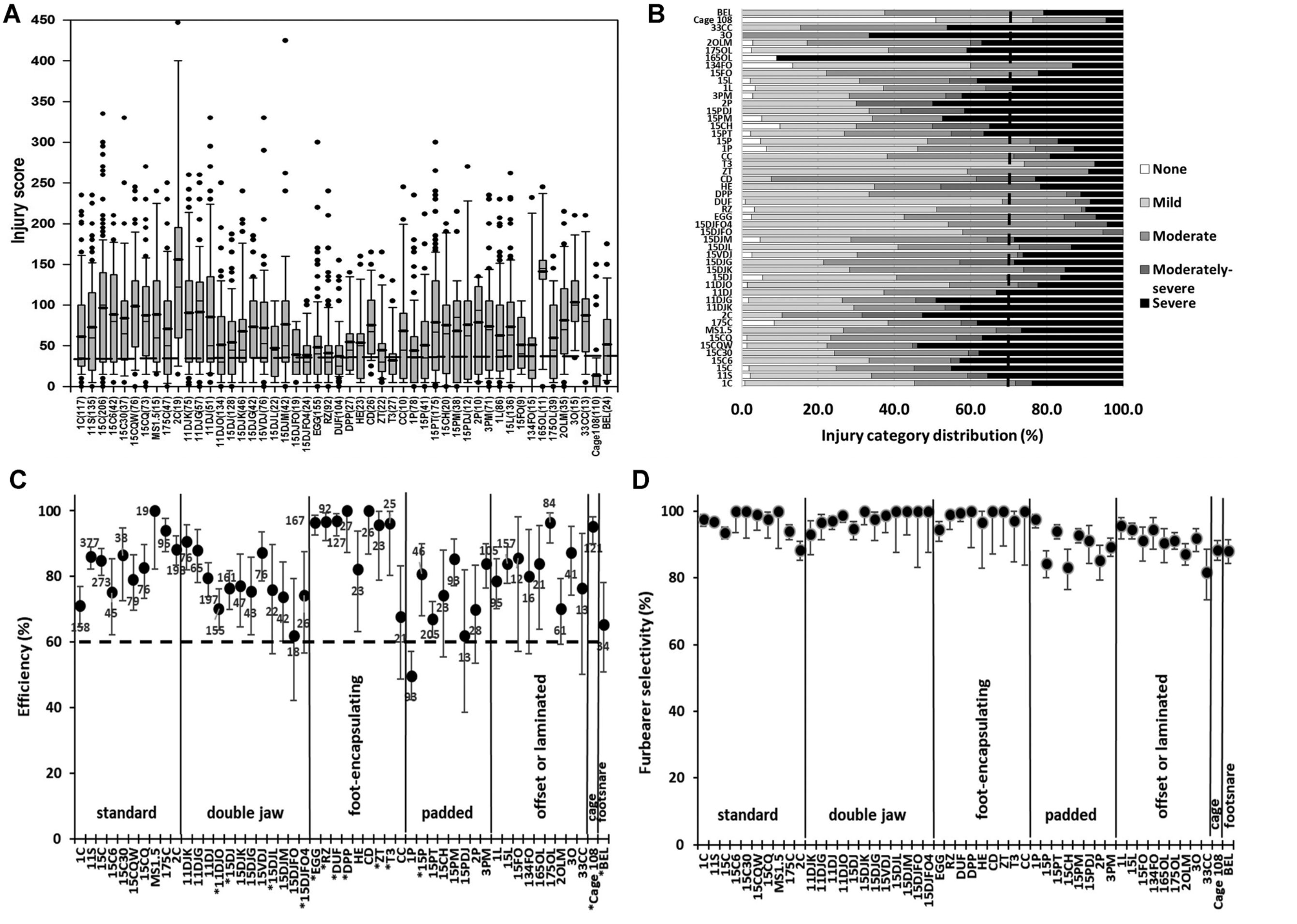

Figure 16. Trap performance profiles for live-restraining traps evaluated on northern raccoons from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of northern raccoons captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of northern raccoons captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

tissue maceration. Compared to standard and double-jaw models, moderate injuries (in the form of chipped or broken teeth) were more common in padded-jaw models (Tables S1 and S26). Overall, an average of 32% of the raccoons sustained severe injuries in padded-jaw models meeting sample size requirements, and 32% exhibited self-directed biting; we did not find any raccoons dead from trap-related stress or injury in padded-jaw traps (Tables S1 and S26). Both injury scores and efficiency generally increased with trap size for padded-jaw models (Fig. 16; Table S25). Five of 6 padded-jaw foothold models meeting sample size requirements passed the BMP efficiency criterion (range = 67–85%) and furbearer selectivity ranged from 83–98% (Fig. 16; Table S25). One padded-jaw foothold model (number 1.5 coil-spring, padded jaws, 2-coil-springs [15P]) tested on raccoons met all BMP criteria (Fig. 16; Table S25).

Of 397 raccoons captured in 4 models of offset- or laminated-jaw coil-spring traps meeting sample size requirements, we conducted post-mortem examinations on 296. None of the 4 models with sufficient samples passed either welfare criterion (Fig. 16; Table S25). The mean cumulative injury score for all offset- or laminated-jaw models meeting sample size requirements was 69.5, similar to double-jaw and padded-jaw footholds. Also similar to both standard- and double-jaw models, the most common injuries in offset- or laminated-jaw models were in the mild category, particularly swelling, minor laceration, minor tissue maceration, and minor periosteal abrasion. However, for traps with adequate sample sizes, these jaw models had the highest percent of animals with severe injuries (36%) and the highest rate of self-directed biting (35%; Tables S1 and S26); we found 2 raccoons dead from trap-related stress or injury in this foothold jaw-type category. Although there was no linear association between trap size and injury scores for these jaw types, the largest traps had the highest injury scores (Fig. 16). Efficiency did not exhibit any correlation with trap size, and ranged from 70–97% for the 4 traps with sufficient samples; furbearer selectivity ranged from 87–96% (Fig. 16; Table S25). None of the offset- or laminated-jaw models tested that met sample size requirements passed all BMP criteria (Fig. 16; Table S25).

Foot-encapsulating traps.—Trappers captured 522 raccoons in 9 models of foot-encapsulating traps with adequate sample size, and we conducted post-mortem examinations on 497. Six of the 9 models passed both animal welfare criteria, 1 failed the injury-score criterion, 1 failed the lower-trauma criterion, and 1 failed both injury criteria. The mean injury score for all foot-encapsulating models was 50.7, lower than the average for any foothold trap regardless of jaw type (Fig. 16; Table S25). The most common injuries from foot-encapsulating traps were mild edema, minor lacerations, and minor subcutaneous soft tissue maceration or erosion (Tables S1 and S26). Overall, an average of 13% (or 9%, considering only passing traps) of animals captured in this trap type had severe injuries and an average of 4.3% exhibited self-directed biting, the lowest for any foot-restraining type of trap we evaluated. Excluding the foot-encapsulating trap with an atypical design (HE, which has a tube attached to the pan of a standard-jaw foothold trap; Appendix A), an average of 1.6% of raccoons exhibited self-directed biting. We did not find any raccoons dead from trap-related stress or injury in foot-encapsulating traps (Tables S1 and S26). All foot-encapsulating models met the capture efficiency criterion (range = 68–100%), and all had high (>94%) furbearer selectivity (Fig. 16; Table S25). Of the 9 models of foot-encapsulating traps with sufficient sample size, 6 met all BMP criteria for live-restraining raccoons and 3 failed at least 1 welfare criterion (Fig. 16; Table S24).

Footsnares.—Using the power-activated footsnare (BEL; Appendix A), trappers captured 34 raccoons and we assessed injuries on 24 (Fig. 16; Table S25). The mean injury score was 51.8 and 79% of the captured raccoons sustained only lower-trauma injuries (Fig. 16; Table S25). The most common injuries were mild edema and minor soft tissue maceration; self-directed biting was reported in 6 (25%) raccoons, and we did not find any raccoons captured in the BEL dead from trap-related stress or injury (Tables S1 and S26). The BEL had the second-lowest capture efficiency across all traps with sufficient samples, and furbearer selectivity was 88% (Fig. 16; Table S25). The BEL met all BMP criteria for capturing raccoons (Fig. 16; Table S25).

Cage traps.—Trappers captured 121 raccoons in 1 model of wire-mesh cage trap (Cage 108; Appendix A) and we examined 110 for trap-related injuries. The Cage 108 had the lowest mean cumulative injury score (13.8) for any restraining trap tested on raccoons (Fig. 16; Table S25). Greater than 95% of the captured raccoons sustained only lower-trauma injuries (Fig. 16; Tables S1 and S26). The most common injuries were mild edema and tooth damage; self-directed biting was reported in 1 (<1% of total) captured raccoon and we did not find any raccoons dead from trap-related stress or injury in the Cage 108 (Tables S1 and S26). Capture efficiency was high (95.3%), and furbearer selectivity was 88.4 (Fig. 16; Table S25). The Cage 108 met all BMP criteria for capturing raccoons (Fig. 16; Table S25).

All traps.—For traps that met sample size requirements, the Cage 108 had the lowest injury score (13.8 points), followed by the overall means for foot-encapsulating traps (50.7), the power-activated footsnare (51.8), padded-jaw footholds (65.3 points), double-jaw footholds (67.9 points), offset- or laminated-jaw footholds (69.5), and standard-jaw footholds (82.6). Self-directing biting was most prevalent in foothold traps (27.4%), of which double-jaw models had the lowest incidence (19%), followed by the footsnare (25.0%), foot-encapsulating traps (4.3%, or 1.6% excluding 1 atypical design), and the cage trap (<1%).

Among all restraining traps that met all criteria for raccoons, capture efficiency was highest for foot-encapsulating traps ($\bar{x} = 95.6\%$) and the cage trap (95.3%), followed by foothold traps ($\bar{x} = 79.5\%$) and the footsnare (65.4%). Furbearer selectivity by trap type, in descending order, was foot-encapsulating traps ($\bar{x} = 98.3\%$), foothold traps ($\bar{x} = 95\%$), the cage trap (88.4%), and the power-activated footsnare (88.1%). Overall, 13 restraining traps met all BMP criteria, 27 devices failed 1 or more criteria (Fig. 16; Table S25), and 10 traps had insufficient samples to reach a conclusion.

Nutria

We evaluated 7 different models of restraining devices (all foothold traps) on nutria, all of which had sufficient sample sizes for BMP assessment. Trappers captured 426 nutria in live-restraining (non-submersion) sets in the Southeast region. We conducted post-mortem examinations on 269. Three of the 7 traps, all padded-jaw models, had cumulative injury scores ≤55 points; of the 4 models that had injury scores >55 points, 1 had padded jaws (Fig. 17; Table S27). Of the 3 foothold traps that met the injury-score criterion (1P, 11CH, 15PT; Appendix A), 2 (1P, 15PT) also met the lower-trauma criterion (Fig. 17; Table S27). Among all foothold traps, mild edema or mild hemorrhage was the most common injury, particularly for padded-jaw traps, with minor cutaneous lacerations and fracture or joint luxation above the carpus or tarsus to a much lesser extent (Tables S1 and S28). One captured nutria showed evidence of self-directed biting, and we did not find any nutria dead from trap-related stress or injury in any of the trap models (Tables S1 and S28). All foothold traps met the capture efficiency criterion (range = 68–97%), with the number 15PT being the most efficient. Furbearer selectivity for these trap models ranged from 94–100% (Fig. 17; Table S27). Overall, 2 restraining devices (1P, 15PT) met all BMP criteria for live restraint, and 5 devices failed 1 or both animal welfare criteria (Fig. 17; Table S27).

Red Fox

Trappers captured 672 red foxes (*Vulpes vulpes*) in 19 models of foothold traps (all coil-spring models) and 1 model of footsnare in Alaska, the Great Plains-West, Midwest, Northeast, and Southeast regions. We conducted post-mortem examinations on 603 red foxes. Fourteen traps had sufficient sample sizes for BMP assessment, including 3 standard-jaw foothold models, 5 padded-jaw foothold models, 5 offset-, laminated-, or wide-jaw models, and the footsnare.

Of 129 red foxes captured in the 3 models of standard-jaw coil-spring traps meeting sample size requirements, we conducted post-mortem examinations on 121. Two of the devices

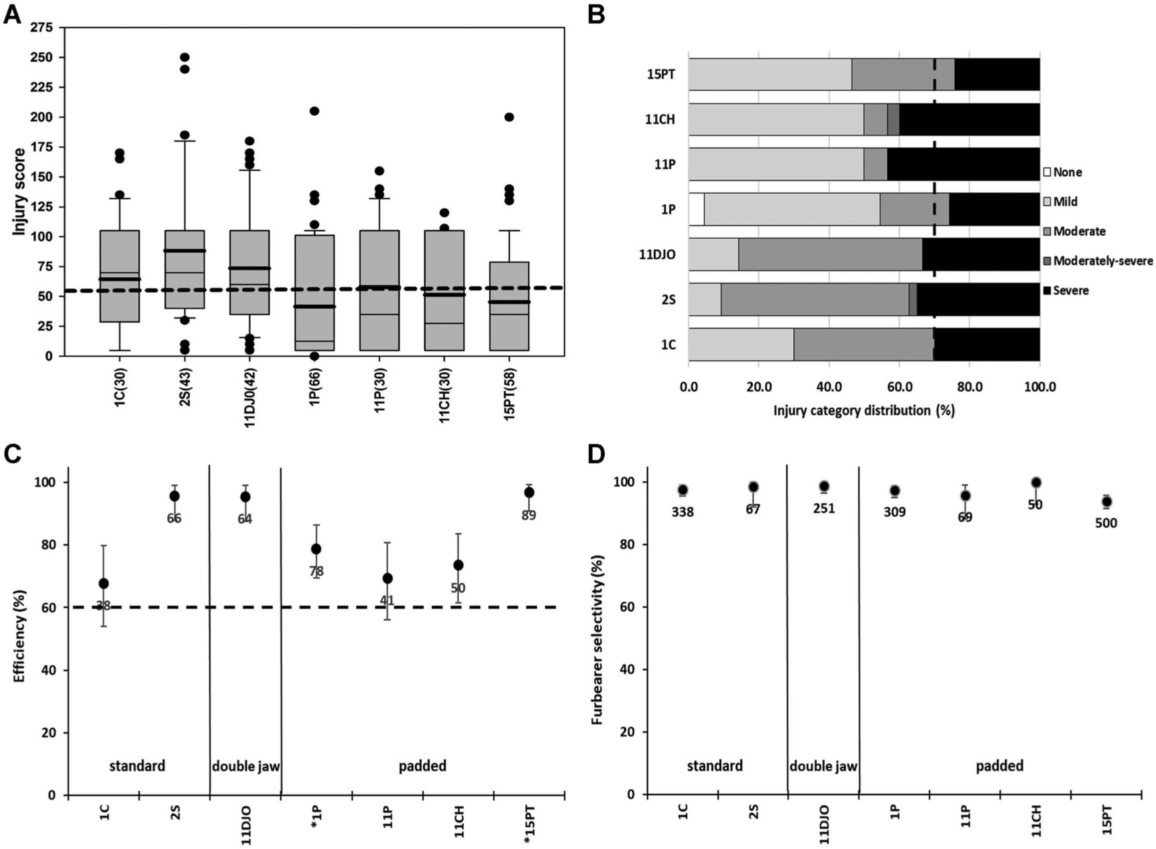

Figure 17. Trap performance profiles for live-restraining traps evaluated on nutria from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of nutria captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of nutria captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

(15C, 175C) passed both welfare criteria, and the 2C failed the injury-score criterion (Fig. 18; Table S29; Appendix A). The mean cumulative injury score for all 3 standard-jaw foothold models meeting sample size requirements was 43.2. The most common injuries in standard-jaw foothold traps were in the mild category, particularly mild edema, minor lacerations, and minor periosteal abrasions; self-directed biting occurred on 1 red fox, and we did not find any red foxes dead from trap-related stress or injury in these devices (Tables S1 and S30). There were few standard-jaw traps on which to gauge the influence of trap size on injury scores or efficiency, though our data suggest no consistent pattern for injury but a decline in efficiency for larger traps (Fig. 18). All standard-jaw foothold models meeting sample size requirements passed the BMP efficiency criterion (range = 80–95%) and furbearer selectivity ranged from 88–94% (Fig. 18; Table S29). Two of the standard-jaw models tested on red foxes passed all BMP criteria, with the third failing the injury-score criterion (Fig. 18; Table S29).

Of 206 red foxes captured in the 5 models of padded-jaw coil-spring traps with sufficient sample sizes, we conducted post-mortem examinations on 179. All 5 of the padded-jaw models passed both welfare criteria (Fig. 18; Table S29). The mean cumulative injury score for the 5 padded-jaw foothold models meeting sample size requirements was 26.0. The most common injuries in padded-jaw foothold traps were in the mild category, particularly mild edema, minor lacerations, and minor periosteal abrasions; self-directed biting occurred with 3 (2%) red foxes, and we did not find any dead from trap-related stress or injury in these devices (Tables S1 and S30). There was no consistent relationship between trap size and injury scores for padded-jaw models, but efficiency generally increased with trap size. All padded-jaw foothold models meeting sample size requirements passed the BMP efficiency criterion (range = 74–94%) and furbearer selectivity ranged from 84–93% (Fig. 18; Table S29). All 5 of the padded-jaw models with sufficient sample sizes passed all BMP criteria for red foxes (Fig. 18; Table S29).

Of 208 red foxes captured in the 5 models of offset-, laminated-, or wide-jaw coil-spring traps that met sample size requirements, we conducted post-mortem examinations on 187. Four of the 5 models passed both welfare criteria

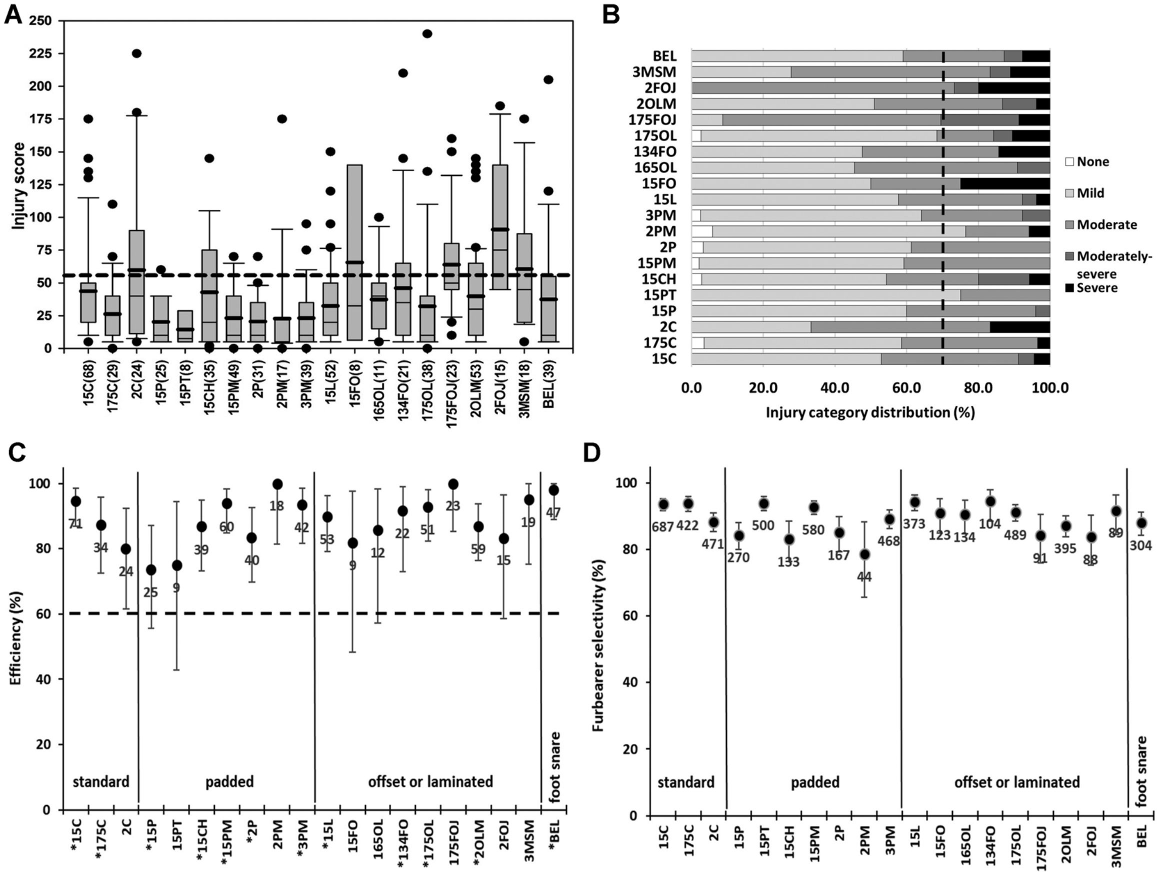

Figure 18. Trap performance profiles for live-restraining traps evaluated on red foxes from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of red foxes captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of red foxes captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

and 1 failed both criteria (Fig. 18; Table S29). The mean cumulative injury score for the 5 traps meeting sample size requirements was 42.8, similar to standard-jaw models. The most common injuries were in the mild category, particularly mild edema, minor lacerations, and minor periosteal abrasions; self-directed biting occurred with 3 (1.6%) red foxes, and we did not find any dead from trap-related stress or injury in these devices (Tables S1 and S30). For this jaw-type category, injury scores generally increased with trap size, with little to no improvement in efficiency (Fig. 18). All traps meeting sample size requirements passed the BMP efficiency criterion (range = 87–100%) and furbearer selectivity ranged from 84–95% (Fig. 18; Table S29). Four of the 5 models with sufficient sample sizes passed all BMP criteria (Fig. 18; Table S29).

We conducted post-mortem examinations on 39 of the 47 red foxes captured in the footsnare (BEL; Appendix A); the mean injury score was 37.4. Approximately 87% of red foxes sustained only lower-trauma injuries (Fig. 18; Table S29). The most common injuries were mild edema, lacerations, and minor periosteal abrasions; there was no evidence of self-directed biting and we did not find any red foxes dead from trap-related stress or injury in the BEL (Tables S1 and S30). The BEL met all criteria for animal welfare and efficiency (98%); furbearer selectivity in this device was 88% (Fig. 18; Table S29). Overall, 12 restraining devices with sufficient sample size met all BMP criteria for red foxes, and 2 failed the welfare criteria (Fig. 18; Table S29).

Ringtail

Trappers captured 20 ringtails (*Bassariscus astutus*) in the Great Plains-West region using a wire-mesh cage trap (Cage 108; Appendix A). The mean cumulative injury score for ringtails captured in this trap was 5.0 (median = 0.0; SE = 3.7; Table S31). All individuals sustained either no (80%), mild (5%), or moderate injuries (15%), and this trap met the lower-trauma criterion (Table S31). The most common injuries were mild edema and tooth damage; no incidence of self-directed biting or trap-related mortality occurred (Tables S1 and S32). Capture efficiency was 100% and furbearer selectivity was 88.4%

for the Cage 108 (Table S31). This restraining device met all BMP criteria (Table S31). To date, we have not evaluated any other live-restraining devices on ringtails.

Striped Skunk

Trappers captured 320 striped skunks in 14 live-restraining devices in the Great Plains-West, Midwest, Northeast, and Southeast regions. We conducted post-mortem examinations on 188 skunks. Most striped skunk captures were incidental during projects targeting other species, with the exception of 1 cage trap project where striped skunks were the focal species. We met required sample sizes for only 3 of the 14 devices that captured skunks (Fig. 19; Table S33).

The number 1 coil-spring foothold trap with double jaws (1DJ; Appendix A) did not meet either animal welfare criterion (Fig. 19; Table S33), but capture efficiency was 100%. Considering all 11 foothold traps regardless of sample size, only 1 model (number 1.65 coil-spring with offset laminated jaws [165OL]; $n = 8$) currently meets the welfare thresholds. Across all models with sample size >8, an average of 57% of striped skunks exhibited severe injuries, and self-directed biting occurred in an average of 44% of the skunks; we did not find any skunks dead as a result of trap-related stress or injury. No foothold traps currently meet all BMP criteria for striped skunks (Fig. 19; Table S33).

Trappers captured 70 striped skunks in 2 models of cage traps (Cage 105.5, Cage 108; Appendix A), of which we conducted post-mortem examinations on 51 (Fig. 19; Table S33). No animals exhibited any injury (Tables S33 and S34), we did not find animals dead from trap-related stress or injury, and both cage traps had 100% efficiency on striped skunks (Fig. 19; Table S33). Furbearer selectivity was higher in the smaller Cage 105.5 (96% vs. 88%), and both met all BMP criteria (Fig. 19; Table S33).

Trappers incidentally captured 18 striped skunks in the footsnare (BEL; Appendix A), of which 8 were necropsied (Fig. 19; Table S33). Although sample size is too low for BMP evaluation, this trap had the second-highest injury score (106.3; Fig. 19; Table S33), with 63% of animals exhibiting severe injuries and 63% with indications of self-directed biting (Fig. 19; Tables S1 and S34); we doubt the trap would pass welfare criteria if additional samples were obtained. Efficiency of the BEL

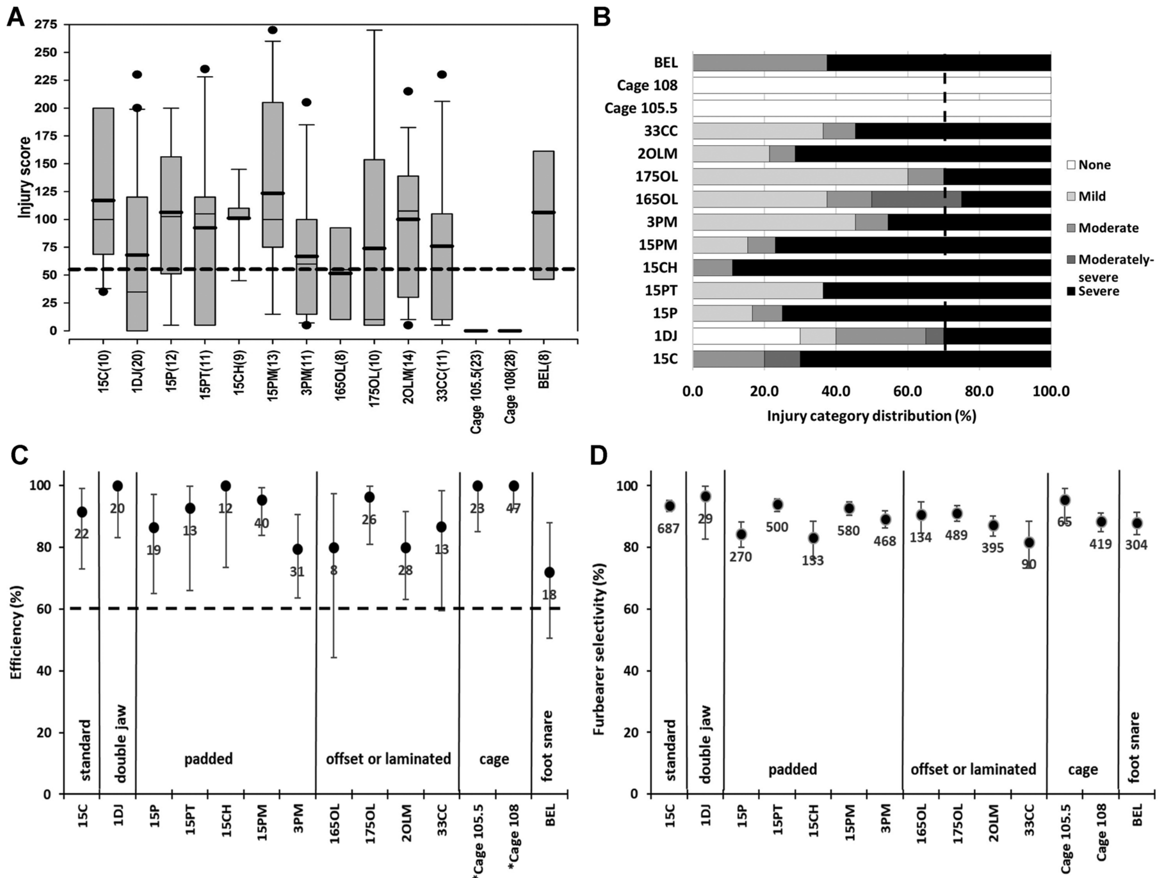

Figure 19. Trap performance profiles for live-restraining traps evaluated on striped skunks from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of striped skunks captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of striped skunks captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

on striped skunks was also lower (72%) than for other tested traps, and furbearer selectivity was 88% (Fig. 19; Table S33). For all restraining devices evaluated on striped skunks that met sample size, currently only the 2 cage traps pass all BMP criteria (Fig. 19; Table S33).

Swift and Kit Foxes

We tested 2 models of number 1 coil-spring foothold trap (standard jaws [1C] and padded jaws [1P]) and 1 model of wire-mesh cage trap (Cage 108; Appendix A) on swift and kit (*Vulpes macrotis*) foxes. Trappers captured 66 swift and kit foxes in the Great Plains-West and Midwest regions, of which we necropsied 64.

Although the mean injury score for the 1P was much lower than for the 1C (67 vs. 100), neither model met either injury criterion (Fig. 20; Table S35). The most common injuries in foothold traps included mild edema and hemorrhage, and minor subcutaneous soft tissue maceration (Tables S1 and S36). However, failing injury scores appear largely a result of a high percentage of animals also exhibiting major skeletal muscle degeneration (Tables S1 and S36) in their limbs (a moderately severe injury), presumably a result of lunging while in the trap. One animal showed indications of self-directed biting, and we did not find any individuals dead from trap-related stress or injury (Tables S1 and S36). The 1C had higher efficiency than the 1P (95% vs. 81%), and furbearer selectivity in these traps was identical (98%). Neither device met all BMP criteria (Fig. 20; Table S35).

Fifty-five percent of swift and kit foxes captured in the Cage 108 ($n = 20$) sustained no injuries, with a mean injury score of 13.5 (Fig. 20; Table S35). Of the foxes with injuries, all were in the lower-trauma category (Fig. 20; Table S35); the only trauma reported was tooth damage, of which 45% showed evidence (Tables S1 and S36). There was no evidence of self-directed biting or mortality from trap-related stress or injury in the Cage 108 (Tables S1 and S36). Efficiency of this cage trap on swift and kit foxes was 81%, and furbearer selectivity was 88% (Fig. 20; Table S35). The Cage 108 was the only swift and kit fox restraining trap we tested that met all BMP criteria (Fig. 20; Table S35).

Virginia Opossum

We collected data on Virginia opossums in 26 models of foothold traps (19 with BMP-sufficient sample size), 2 models

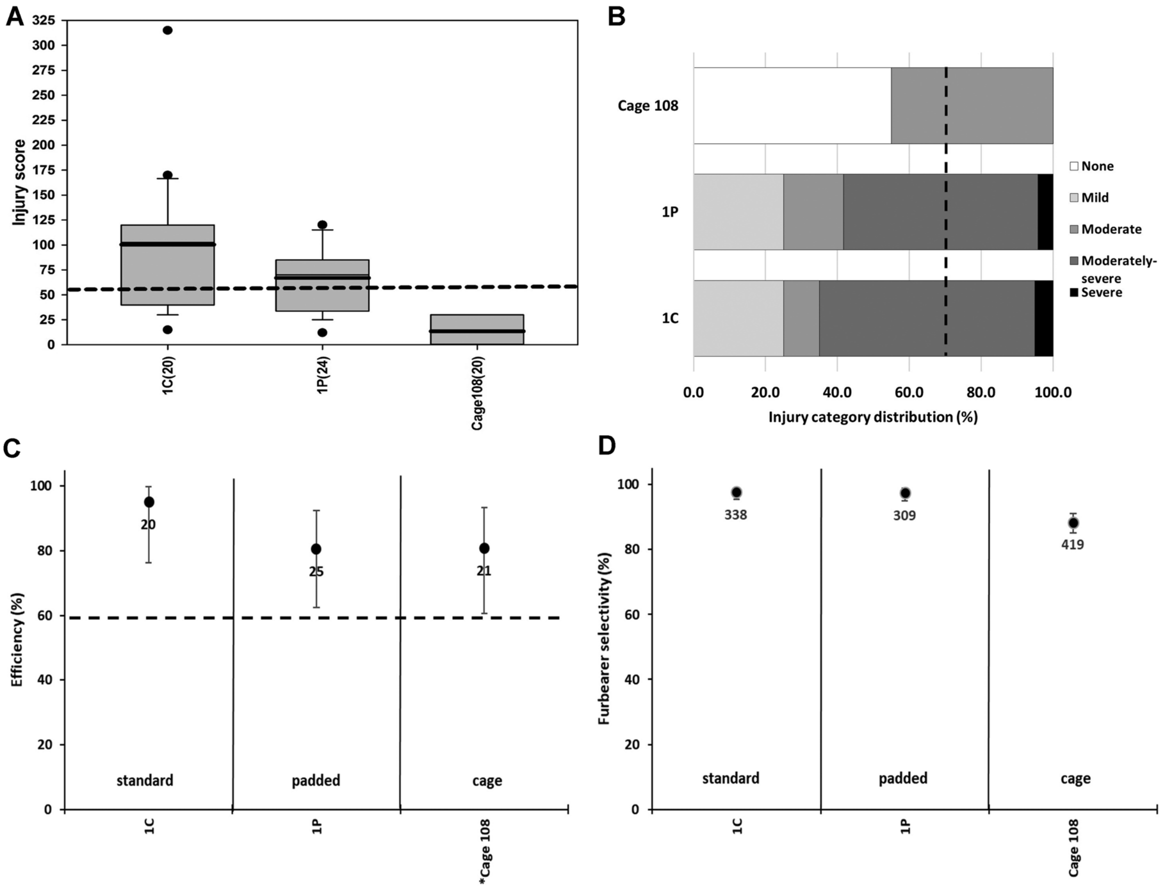

Figure 20. Trap performance profiles for live-restraining traps evaluated on swift and kit foxes from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of swift and kit foxes captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of swift and kit foxes captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

of foot-encapsulating traps, 1 model of cage trap, and 1 model of power-activated footsnare. As with striped skunks, most Virginia opossums captured during our study were incidental on projects targeting other species. Trappers captured 1,715 opossums in the Great Plains-West, Midwest, Northeast, and Southeast regions, of which we conducted post-mortem examinations on 954.

Foothold traps.—Of 204 Virginia opossums captured in 2 models of standard-jaw coil-spring traps (number 1 coil-spring [1C], number 1.5 coil-spring [15C]; Appendix A) with sufficient sample size, we conducted post-mortem examinations on 107. Both standard-jaw foothold models failed both injury criteria (Fig. 21; Table S37). The mean cumulative injury score for these 2 standard-jaw foothold models was 87.6. Opossums exhibited numerous types of injuries, including those categorized as mild (swelling, minor laceration, and minor periosteal abrasion), moderate (chipped or fractured teeth, major subcutaneous maceration), and severe (fracture or joint luxation above the carpus or tarsus (Tables S1 and S38). None captured in the 1C exhibited self-directed biting or died from trap-related stress or injury. In the 15C, 4 (5.1%) animals exhibited self-directed biting, and we did not find any dead from trap-related stress or injury (Tables S1 and S38). Though several models had insufficient sample sizes, injury scores increased with trap size for standard-jaw footholds. Both standard-jaw foothold models meeting sample size requirements had similar efficiency (95–96%) and furbearer selectivity (94–98%); no trend in efficiency was apparent with increasing trap size for standard-jaw models, but furbearer selectivity slightly declined with trap size (Fig. 21; Table S37). Neither standard-jaw foothold passed all BMP criteria for opossums (Fig. 21; Table S37).

Of 147 opossums captured in 5 models of double-jaw coil-spring traps meeting sample size requirements, we conducted post-mortem examinations on 128. One of the 5 models (number 1.5 coil-spring with double jaws [15DJ]; Appendix A) passed both welfare criteria, with a mean injury score at the BMP threshold (55.0; Fig. 21; Table S37). The average cumulative injury score for all 5 models pooled was 68.5. Similar to standard-jaw models, opossums captured in double-jaw models exhibited numerous types of injuries, including those categorized as mild (swelling, minor laceration, and minor periosteal abrasion), moderate (chipped or fractured teeth, major

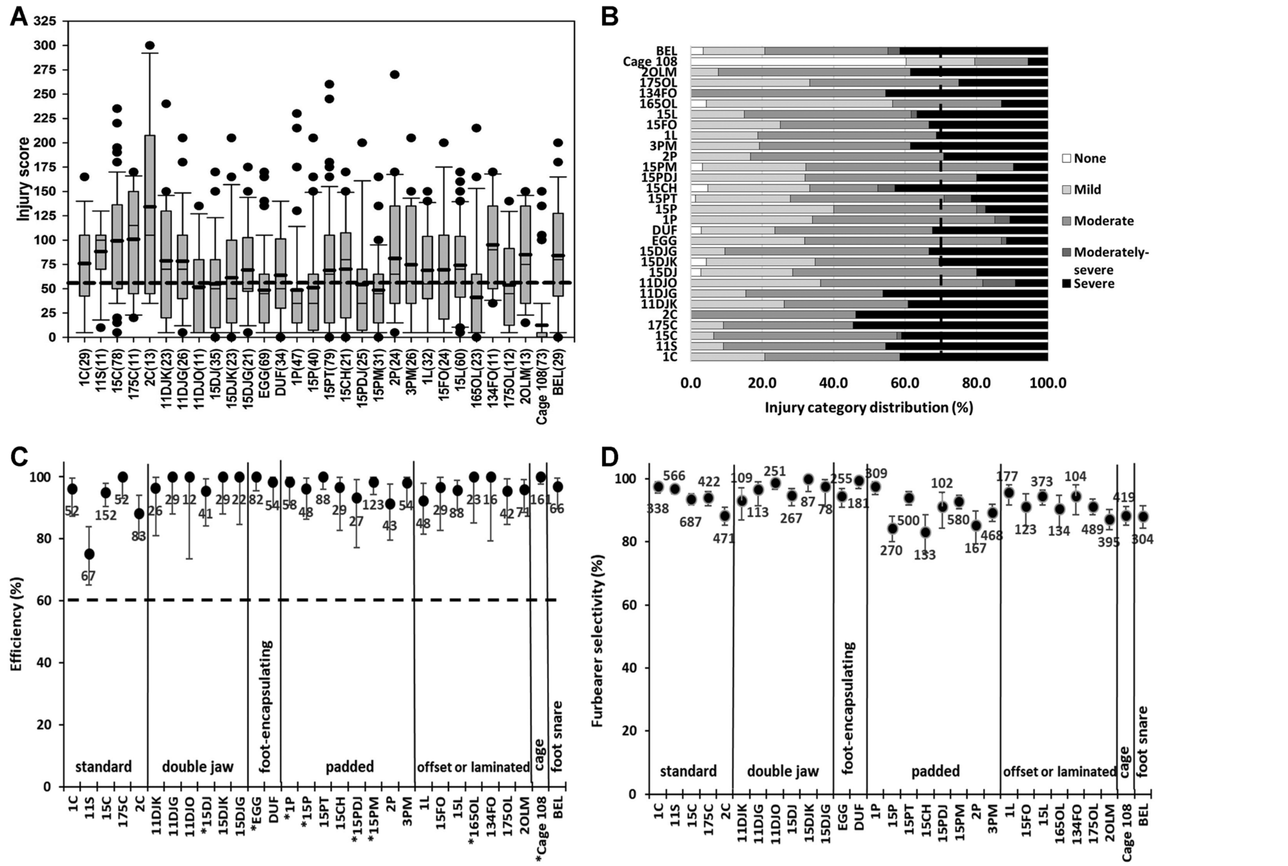

Figure 21. Trap performance profiles for live-restraining traps evaluated on Virginia opossums from 1997–2018 during development of best management practices (BMP) for trapping in the United States. A) Trap-specific boxplots of cumulative injury scores for all animals necropised; thick line represents mean, thin line represents median. Necropsy sample size is shown in parentheses after *x*-axis trap labels. B) Injury severity class distribution (%) for the most severe injury each animal incurred; necropsy sample sizes are the same as in A. C) Efficiency (% of Virginia opossums captured that activated the trap); error bars represent 95% confidence intervals, and numeric labels represent number of Virginia opossums captured. D) Furbearer selectivity (%); error bars represent 95% confidence intervals, and numeric labels represent total number of furbearers captured in each trap type. All graphs have traps organized by broad type (e.g., cage trap, footsnare, foot-encapsulating trap) or by jaw type (standard, double, padded, and offset or laminated) for foothold traps, and are generally ordered in increasing size from left to right within each type. Dashed lines represent metric-specific BMP thresholds and an asterisk preceding a trap code in panel C denotes a trap that met sample size requirements and passed all BMP criteria. Detailed explanation of trap codes can be found in Appendix A.

subcutaneous maceration), and severe (fracture or joint luxation above the carpus or tarsus; Tables S1 and S38). Two (1.5%) animals captured in these 5 models exhibited self-directed biting, and we did not find any opossums dead from trap-related stress or injury (Tables S1 and S38). Efficiency was high (>95%) for all 5 models, as was furbearer selectivity (93–100%; Fig. 21; Table S37). Although there was some variation in trap sizes for the models evaluated, there was no obvious association between trap size and injury, efficiency, or furbearer selectivity (Fig. 21). One double-jaw foothold tested on opossums passed all BMP criteria (Fig. 21; Table S37).

Of 470 opossums captured in 8 models of padded-jaw coil-spring traps that met sample size requirements, we conducted post-mortem examinations on 293. Four of the 8 models passed both welfare criteria, and 4 failed 1 or both criteria (Fig. 21; Table S37). The mean cumulative injury score for all 8 padded-jaw foothold models was 62.2. As with standard- and double-jaw models, opossums captured in padded-jaw models exhibited numerous types of injuries (Tables S1 and S38), including those categorized as mild (swelling, minor laceration, and minor periosteal abrasion), moderate (chipped or fractured teeth, major subcutaneous maceration), and severe (fracture or joint luxation above the carpus or tarsus). The average percentage of severe injuries was lower (15% vs. 33%) for the 4 padded-jaw models that passed welfare criteria than those that did not (Tables S1 and S38). Seventeen (5.8%) of the 293 opossums necropsied exhibited evidence of self-directed biting, and we did not find any opossums captured in padded-jaw models dead from trap-related stress or injury (Tables S1 and S38). Efficiency was high (>91%) for all 8 models, and furbearer selectivity ranged from 83–98% (Fig. 21; Table S37). There was no obvious correlation between trap size and efficiency or furbearer selectivity, but injury scores slightly increased with trap size for padded-jaw models (Fig. 21). Four models of padded-jaw trap meeting sample size requirements passed all BMP criteria, and 4 failed the welfare criteria (Fig. 21; Table S37).

Of 188 opossums captured in 4 models of offset-, laminated-, or wide-jaw coil-spring traps that met sample size requirements, we conducted post-mortem examinations on 139. One model, the largest of the 4 (number 1.65 coil-spring with offset laminated jaws [165OL]; Appendix A), passed both welfare criteria. The mean injury score for the 165OL was 41.1 (Fig. 21; Table S37), compared to 63.4 for all 4 models combined. Opossums captured in these foothold jaw types exhibited injuries similar to other jaw types, including those classified as mild (swelling, minor laceration, and minor periosteal abrasion), moderate (chipped or fractured teeth, major subcutaneous maceration), and severe (fracture or joint luxation above the carpus or tarsus); the 1 model that passed welfare criteria had a lower percentage of severe injuries (Tables S1 and S38). Eight (5.8%) of the 139 opossums necropsied exhibited evidence of self-directed biting, and we did not find any opossums captured in these jaw types dead from trap-related stress or injury (Tables S1 and S38). Efficiency was high (>92%) for all 4 models with adequate sample size, and furbearer selectivity ranged from 91–96% (Fig. 21; Table S37). There was no obvious association between trap size and cumulative injury score, efficiency, or furbearer selectivity (Fig. 21). For the 4 models of offset-, laminated-, or wide-jaw coil-spring traps that met sample size requirements, the 165OL passed all BMP criteria, and 3 failed the welfare criteria (Fig. 21; Table S37).

Foot-encapsulating traps.—We conducted post-mortem examinations on 103 of 136 opossums captured in 2 foot-encapsulating traps (DUF, EGG; Appendix A). The EGG met both criteria for animal welfare, whereas the DUF failed both criteria (Fig. 21; Table S37). For both traps, the most common injuries were mild edema, mild lacerations, and major subcutaneous soft tissue maceration or erosion; the primary difference was that the DUF had a higher percentage of animals with fractures at or below the carpus or tarsus (i.e., a severe injury; Tables S1 and S38). We observed evidence of self-directed biting in 5 (3.7%) animals, 4 being in the EGG; we did not find any animals dead from trap-related stress or injury (Tables S1 and S38). Both foot-encapsulating traps had capture efficiency >98% and furbearer selectivity ≥94% (Fig. 21; Table S37). The EGG met all BMP criteria, whereas the DUF failed the welfare criteria (Fig. 21; Table S37).

Cage traps.—Trappers captured 161 opossums in the Cage 108 (Appendix A) and we conducted a post-mortem examination on 73. The Cage 108 had the lowest mean cumulative injury score (12.5) of all restraining traps tested on opossums (Fig. 21; Table S37). Approximately 95% of opossums captured in the Cage 108 sustained injuries in only the lower-trauma categories (Fig. 21; Table S37). The most common injury we observed was mild edema; no self-directed biting or trap-related mortalities occurred (Tables S1 and S38). The Cage 108 met all BMP welfare and efficiency criteria, and furbearer selectivity was 88.4% (Fig. 21; Table S37).

Footsnares.—Of 66 Virginia opossums captured in the power-activated footsnare (BEL; Appendix A), we conducted a post-mortem examination on 29 individuals. The mean cumulative injury score in the BEL was 84.0 (Fig. 21; Table S37). Approximately 55% of opossums captured in the BEL sustained only lower-trauma injuries (Fig. 21; Table S37). The most common injuries observed were mild edema and minor laceration; we detected self-directed biting in 1 animal and we did not find any opossums dead from trap-related stress or injury in the BEL (Tables S1 and S38). The BEL did not meet either animal welfare criterion, but did meet the efficiency criterion (97%); furbearer selectivity was 88.1%, the fourth lowest of all restraining traps tested on opossums (Fig. 21; Table S37). Overall, 8 of the 23 restraining devices evaluated on Virginia opossums met all BMP criteria (Fig. 21; Table S37).

Multi-Species Comparisons

Injury scores.—Sample sizes were sufficient to allow a comparison of mean injury score for 21 trap-species pairs across >1 states or state-groupings, including 2 traps for bobcats, 6 traps for coyotes, 2 traps for gray foxes, 3 traps for opossums, and 8 traps for raccoons (Fig. 22). Of the 21 comparisons we were able to conduct, injury scores were statistically different ($P < 0.05$) for 2 comparisons; the mean injury score for the number 1.5 padded-jaw trap with 4 coil-springs (15PM) was higher for coyotes in South Dakota-Wyoming than in Maine-Vermont, and the mean injury score for the number 1.5 padded-jaw trap with 2 stronger coil-springs (15PT) was higher for raccoons in midwestern states where the trap was tested (i.e., Kansas-Missouri-Wisconsin)

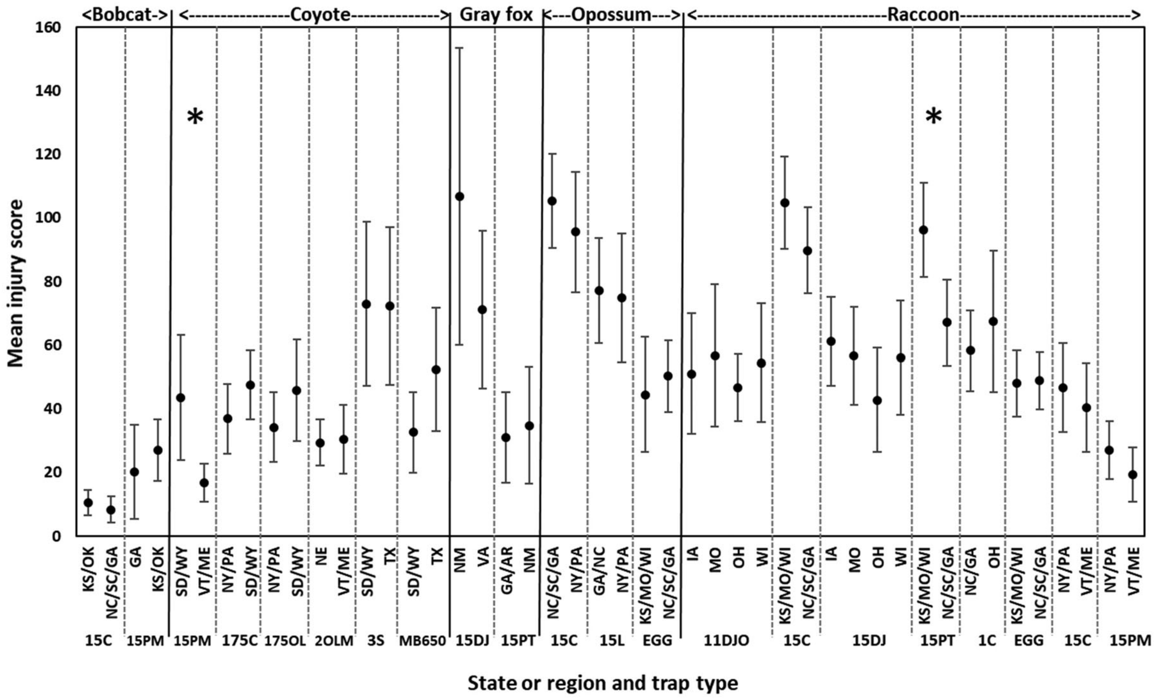

Figure 22. Comparison of mean injury score between states or state groups for 21 trap-species combinations where group-specific sample size was ≥17 during best management practices trap testing in the United States, 1997–2018. Error bars represent 95% confidence intervals. Asterisk denotes a significant difference ($P < 0.05$) in mean injury score between groups. Detailed explanation of trap codes can be found in Appendix A.

than in southeastern states (i.e., North Carolina-South Carolina-Georgia).

Across taxonomic groupings, injury scores were lowest for felids (Fig. 23), which primarily consisted of bobcats in our dataset. Canid and mustelid injury scores were also generally lower than for didelphids, procyonids, and rodents, with minimal differences in average injury scores across the latter 3 taxonomic groups (Fig. 23). Injury scores also generally decreased with increasing body-size class (Fig. 24).

With species pooled, cage traps had the lowest average injury score and there was minimal variation across the other 3 trap-type categories (Fig. 25). We did not test all trap types on all species or species groupings, but this pattern was largely consistent across taxonomic groups and body-size classes (Fig. 25). The greater average injury score for the footsnare in both the mustelid family and medium-small body-size class is largely a result of higher injury in striped skunks, though sample size for striped skunks in this trap is currently below the minimum required for BMP assessment.

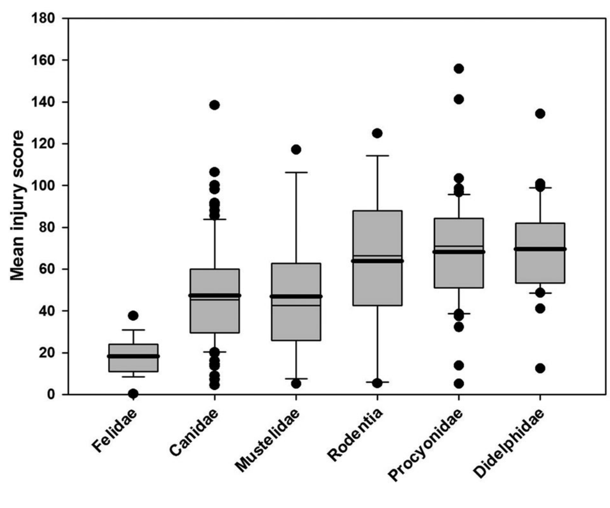

Figure 23. Distribution of mean injury scores by taxonomic group across all traps tested during best management practices trap testing in the United States, 1997–2018. The overall mean for each group is represented by the thick line, and the median by the thin line.

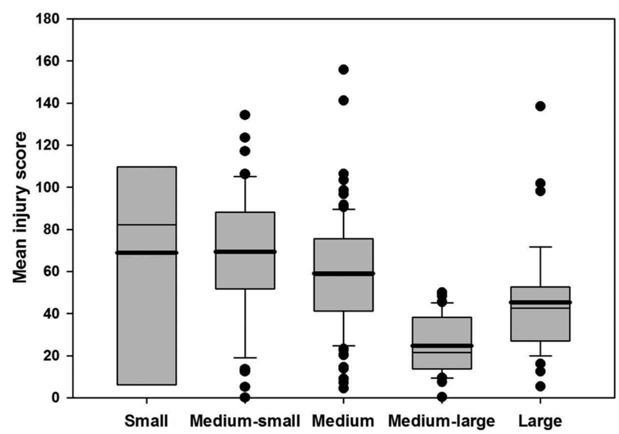

Figure 24. Distribution of mean injury scores across all traps tested on species grouped by body-size classes (small: muskrats, ringtails; medium-small: swift and kit foxes, opossums, fishers, and striped skunks; medium: Arctic, red, and gray foxes, raccoons, and nutria; medium-large: badgers, bobcats, lynx, and river otters; large: coyotes, wolves, and beavers) during best management practices trap testing in the United States, 1997–2018. The overall mean for each group is represented by the thick line, and the median by the thin line.

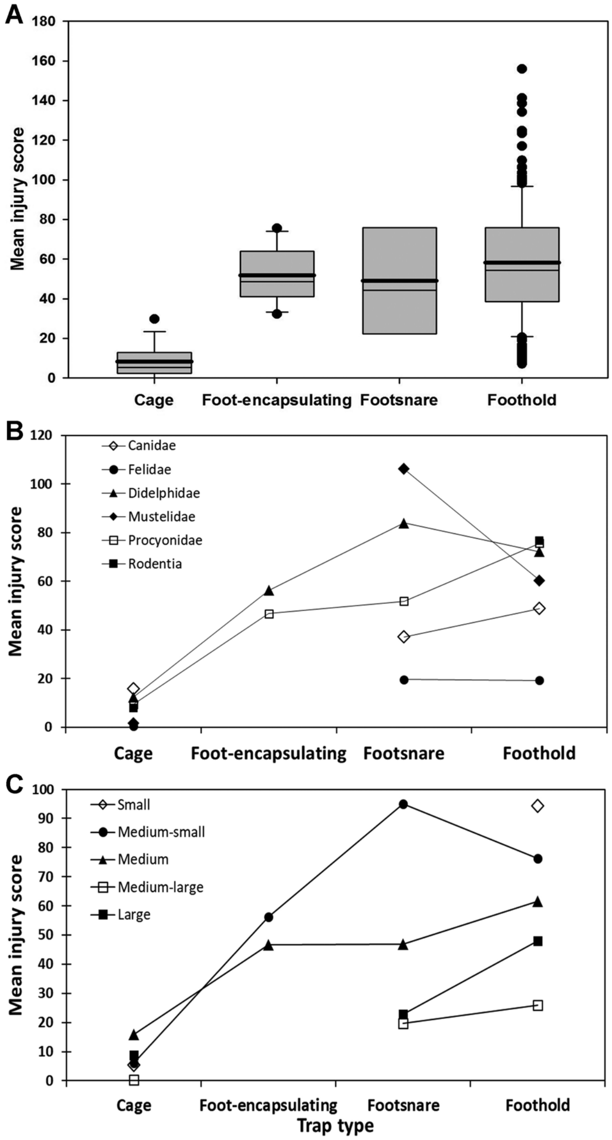

Figure 25. Distribution of mean injury scores by trap type for all species pooled (A), and mean scores for trap types by taxonomic group (B) and by body-size classes (C; small: muskrats, ringtails; medium-small: swift or kit foxes, opossums, fishers, and striped skunks; medium: Arctic, red, and gray foxes, raccoons, and nutria; medium-large: badgers, bobcats, lynx, and river otters; large: coyotes, wolves, and beavers) during best management practices trap testing in the United States, 1997–2018. Connecting lines in B and C are used only to facilitate comparison of patterns among groups.

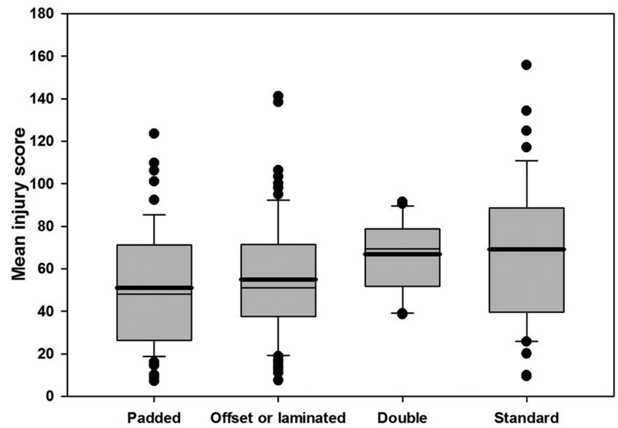

Figure 26. Distribution of mean injury scores by jaw type for all foothold traps evaluated (species pooled) during best management practices trap testing in the United States, 1997–2018. The overall mean for each jaw type is represented by the thick line, and the median by the thin line.

With species pooled, we did not observe any difference in average injury scores between standard-jaw and double-jaw foothold models, or between offset-laminated and padded-jaw models (Fig. 26). However, injury scores for the latter 2 jaw types were on average lower than the former 2 jaw types (Fig. 26). Although data were sparse for some groupings, there were no obvious exceptions to this pattern across taxonomic groups or body-size classes.

Although there were some patterns in species-specific injury scores as a function of foothold trap size, there was no overall (i.e., species pooled) trend in average injury scores as foothold trap size increased (Fig. 27). Data for some sub-groupings were often sparse, but the only potential exceptions to this observation for any jaw type, taxonomic, or body-size sub-groupings were slight increases in injury scores with increasing trap size for canids and procyonids, and a moderately increasing trend for the large body-size class (with data dominated by coyote testing; Fig. 28).

Averaged across all traps tested, self-directed biting was absent or very rare (≤2% of animals) for most species, rare (4–7%) for 4 species (badgers, gray foxes, Virginia opossums, and North American river otters), and most common for raccoons (21%) and striped skunks (39%; Fig. 29). There was a statistically significant, albeit relatively low, correlation between mean injury scores and the percentage of animals exhibiting self-directed biting ($r = 0.49$, $P < 0.001$). Self-directed biting was least common in cage traps, and highest for footsnares (Fig. 29). For foothold traps, jaw type did not appear to have a strong influence on propensity for self-directed biting (Fig. 29), with the

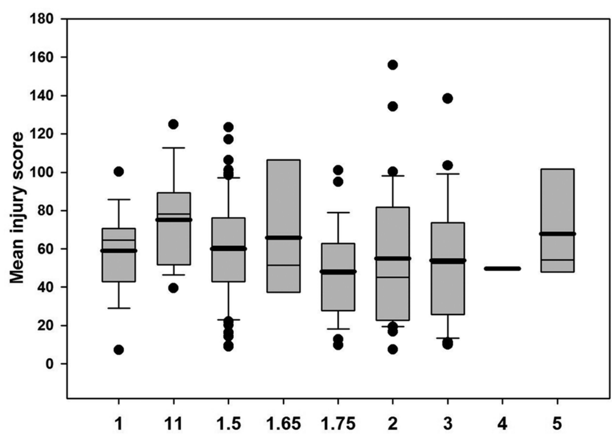

Figure 27. Distribution of mean injury scores by foothold trap size for all species pooled during best management practices trap testing in the United States, 1997–2018. The overall mean for each trap size is represented by the thick line, and the median by the thin line. Trap sizes on the *x*-axis are based on the common nomenclature used by trap manufacturers. Although this nomenclature is typically associated with trap jaw spreads, it is not an actual measurement in itself.

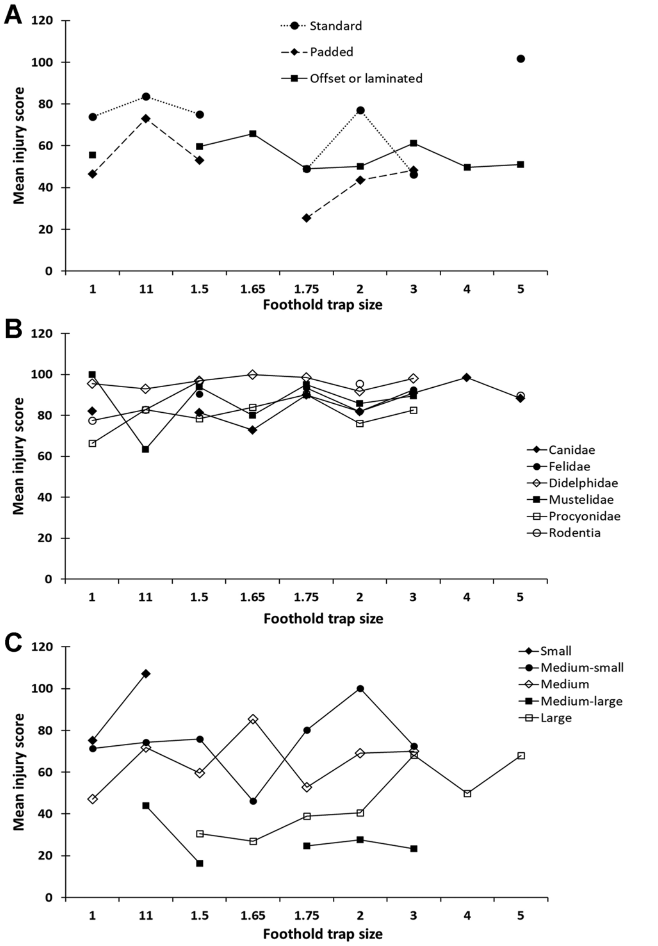

Figure 28. Mean injury score for each foothold trap size by jaw type (A), taxonomic group (B), and body-size class (C) during best management practices trap testing in the United States, 1997–2018. Trap sizes on the *x*-axis are based on the common nomenclature used by trap manufacturers. Although this nomenclature is typically associated with trap jaw spreads, it is not an actual measurement in itself. Connecting lines are used only to facilitate comparison of patterns among groups.

exception of raccoons for which double-jaw models did reduce self-directed biting compared to other foothold jaw types.

Capture efficiency.—Average capture efficiency was typically high ($\bar{x} = 86\%$) and few trap models failed the efficiency criterion for any species. There were some differences in average capture efficiency across taxonomic groups (Fig. 30); efficiency was the greatest for opossums (96%), intermediate for mustelids and felids (87–89%), and slightly lower for canids, rodents, and procyonids (82–85%); observed differences across groups were not practically significant for many trapping situations. Capture efficiency did not exhibit any consistent trend across body-size classes (Fig. 31).

Capture efficiencies for cage and foot-encapsulating traps (the latter highly selective for raccoons and opossums) were similar and the greatest of the 4 trap types we evaluated (Fig. 32); average efficiency was progressively lower for foothold traps and footsnares, though still remained high (>76%) for both. This pattern (i.e., greatest to least: foot-encapsulating and cage, foothold, footsnare) was generally consistent across taxonomic groups, with the exception of similar capture efficiency for all trap types on opossums and little difference between footholds and footsnares for canids (Fig. 32). Grouping by body-size classes yielded more-unbalanced data for comparison, but these trap-type patterns in efficiency were not notably dissimilar across size groups (Fig. 32).

Average capture efficiency generally increased with foothold trap size (Fig. 33), though the range across trap sizes was not substantial (79–98%). This slightly increasing trend was broadly similar across all body-size classes (Fig. 33), but efficiency increased more rapidly with trap size for the larger species (data dominated by coyote testing). We did not observe any overall difference in average capture efficiency across foothold trap jaw types (Fig. 34). When examined by taxonomic groups or body-size classes, the primary exception to this observation, acknowledging data for some sub-groupings were sparse, was lower efficiency with double-jaw traps for the procyonid, canid, and mustelid groups (Fig. 34), which in this case is largely explained by lower efficiency for raccoons, gray foxes, and river otters, respectively. Lower efficiency for the double-jaw trap in the medium-large body-size class is also a result of poor efficiency on river otters, the only species in this body-size class for which a double-jaw trap was tested, and a species for which all foothold traps we tested had lower efficiency.

Parsing data based on whether each trap model was primarily set (regardless of focal species) on land, in water, or both (i.e., primarily raccoons in our dataset), average capture efficiency was high (>75%) for all categories, but was higher for traps set in terrestrial locations ($\bar{x} = 88.7\%$; 95% CI = 86.9–90.5) than in mixed ($\bar{x} = 81.3\%$; 95% CI = 77.9–84.7) or aquatic ($\bar{x} = 76.2\%$; 95% CI = 66.4–86.1) locations.

Furbearer selectivity.—Across trap types, average furbearer selectivity was consistently high, with footsnares being the lowest (88%) and foot-encapsulating traps being the highest (99%; Fig. 35). There were not any notable differences in furbearer selectivity across either foothold trap sizes or jaw types (Fig. 35). When parsed by locations where traps were set, average furbearer selectivity was consistently high (>93%) but slightly lower in traps deployed only in terrestrial sets than those in mixed-location sets (terrestrial: $\bar{x} = 93.1\%$, 95% CI = 91.5–94.6; mixed: $\bar{x} = 96.1\%$, 95% CI = 94.6–97.6; aquatic: $\bar{x} = 94.7\%$, 95% CI = 87–100).

During the 21 years of trap testing, trappers deployed live-restraining traps for approximately 230,000 trap nights. During this time, trappers did not capture any individuals of a threatened or endangered species. Trappers captured 1,035 non-furbearers (11% of total captures), of which 83% were alive upon trap visitation. The majority of non-furbearers captured were feral or free-ranging cats ($n = 292$, 28% of non-furbearers, 3.4% of total captures), lagomorphs (primarily cottontail rabbits [*Sylvilagus floridanus*]; $n = 219$, 21% of non-furbearers, 2.5% of total captures), feral or free-ranging dogs ($n = 199$, 19% of non-furbearers, 2.3% of total captures), and birds ($n = 139$, 13% of non-furbearers, 1.6% of total captures). Other captures in order of decreasing frequency were small rodents and squirrels, porcupines (*Erethizon dorsatum*), deer (*Odocoileus* spp.), black bears (*Ursus americanus*), frogs, and livestock (2 cows, 1 sheep). Of the 199 feral or free-ranging dogs captured, all were alive, none were deemed to be in need of veterinary care by our technicians, and

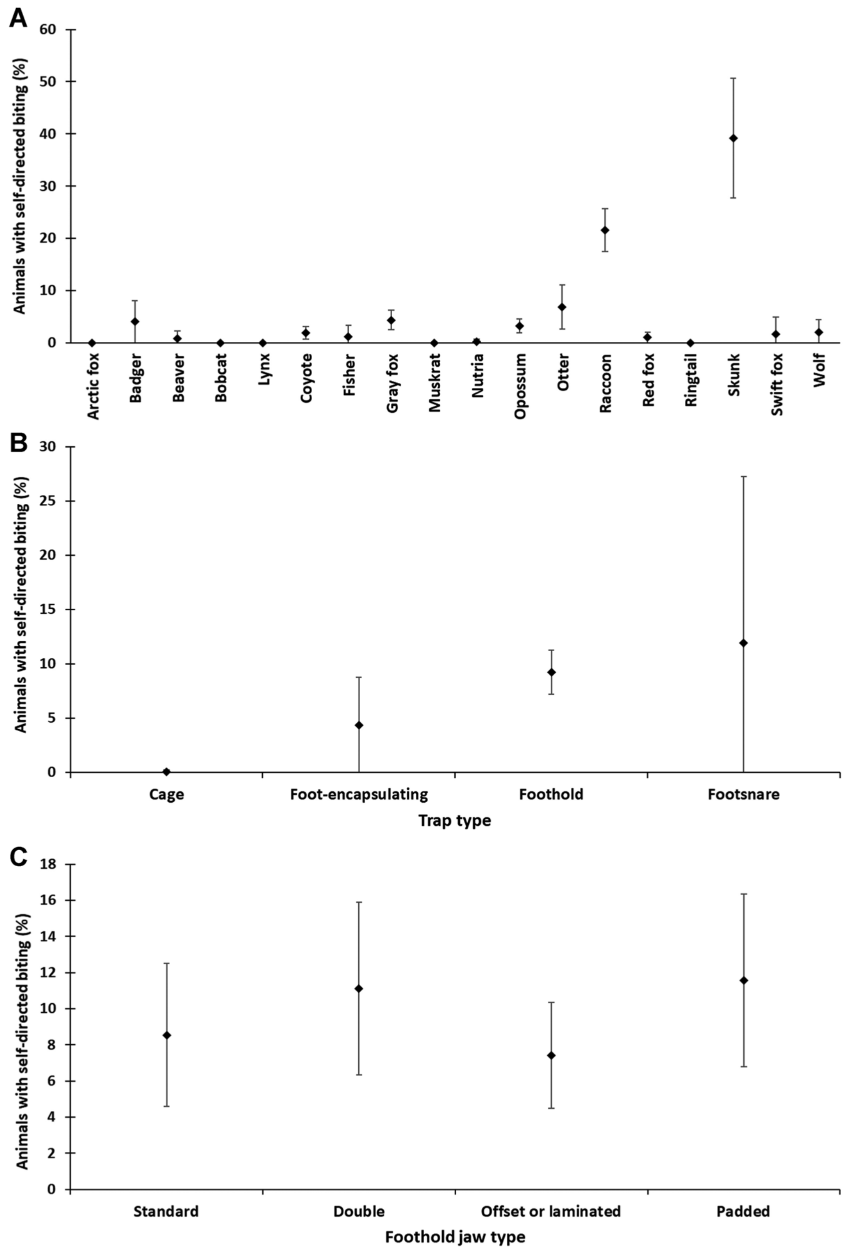

Figure 29. Mean percentage of animals exhibiting self-directed biting by species (A), trap type (B), and foothold jaw types (C) during best management practices trap testing in the United States, 1997–2018. Error bars represent 95% confidence intervals.

no dog owners (when they could be located) requested any veterinary care. Of the 292 feral or free-ranging cats captured, 2 (1%) were dead upon trap inspection. Although confirming the owner of a captured cat was often impossible (we suspect a majority were feral cats), none of the 290 that were alive upon inspection were deemed in need of veterinary care by technicians or any owners that could be located. Nearly all of the 17% of non-furbearers that were dead upon trap inspection were birds, rabbits, and squirrels, sometimes a result of predation while in a trap.

DISCUSSION

Our research was not the first to evaluate traps with the goal of improving animal welfare. For example, Robinson (1959) described the efforts of the American Humane Association and cooperators to conduct a professionally judged humane trap contest. Fall (2002) summarized other modern efforts, particularly those supported by the United States government, that focused on evaluating and addressing concerns about animal welfare, and much research and development has taken place since our initial review of trap testing research conducted over 2 decades ago (IAFWA 1997). In most trap research, numerical scores have typically been used to summarize injury incurred by a trapped animal (Olsen et al. 1986, Linhart et al. 1988, Olsen et al. 1988, Onderka et al. 1990, Phillips et al. 1992, Hubert et al. 1996). Although Linhart and Linscombe (1987) recommended the establishment of a standardized numerical system to rank trap-related injuries, the existence of several

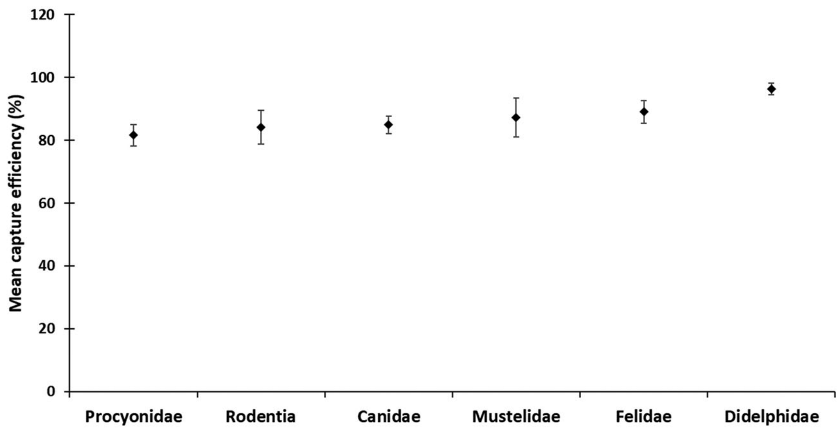

Figure 30. Mean capture efficiency by taxonomic group across all traps tested during best management practices trap testing in the United States, 1997–2018. Error bars represent 95% confidence intervals.

different and contradictory scoring systems has complicated absolute comparisons across studies. We believe the ISO scoring system provided a sound, objective, and repeatable approach that others should use in future trap-testing studies. Our work provides the largest and most standardized trap-injury database in the world for 19 species of mammals captured in a wide variety of restraining traps, and as such should form a central basis for any further consideration of animal welfare in restraining traps.

Demonstrating that trapping devices and methods can be acceptably humane, selective, and efficient is critical for ensuring that traps remain viable tools for use by avocational trappers, wildlife control operators, public health officials, and wildlife managers and researchers (Novak 1987*b*). Batcheller et al. (2000) identified the adoption of BMPs as an essential component of sustaining avocational trapping and the use of traps in furbearer management and research. In 2015, 66% of trappers who were aware of the BMPs used them when making trapping decisions, but more than half of all trappers had no knowledge of the BMPs (Responsive Management 2015). Lack of knowledge about trapping BMPs, although a concern, does not equate with lack of use of traps that in fact meet BMP criteria. Through a comparison of 2015 trap-use data in the United States (Responsive Management 2015; AFWA, unpublished data) with the list of BMP-compliant traps, we estimate that roughly 75% of all target furbearers trapped in the United States were (in 2015) taken in BMP-compliant traps, and an additional 10% were taken in traps not yet tested.

We continue to engage in a multifaceted outreach effort to avocational trappers and wildlife professionals, including through training workshops and online resources for wildlife agency staff and trappers (AFWA 2017*a*), presentations at wildlife conferences, attendance at state and national trapping conventions to discuss and distribute BMPs, writing articles in popular trapping magazines, and development of an online BMP trap-search portal (AFWA 2019). We also plan to continue periodic national surveys to assess changes in trap use in the United States, and encourage all wildlife managers and agencies, educational and research institutions, and those within the trapping community (Krause 2007) to continue trap research efforts and improve or expand trapping-related education and outreach.

For each trap we tested, we relied on multiple experienced trappers, typically in multiple states, to capture animals. Our

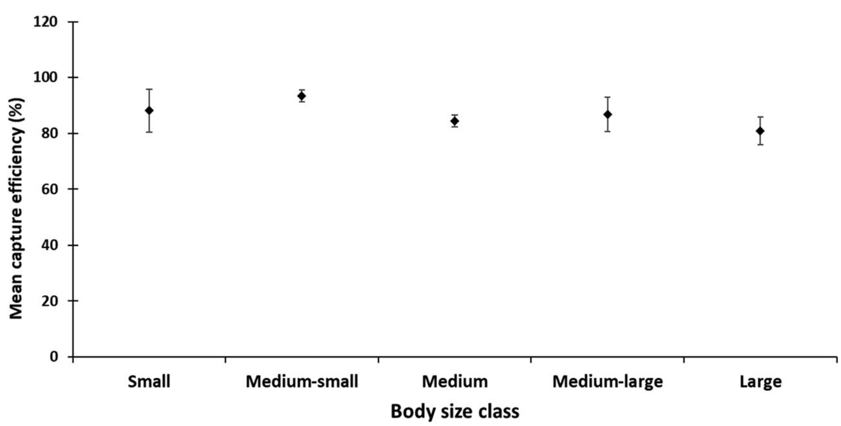

Figure 31. Average capture efficiency (all traps pooled) by body-size classes (small: muskrats, ringtails; medium-small: swift and kit foxes, opossums, fishers, and striped skunks; medium: Arctic, red, and gray foxes, raccoons, and nutria; medium-large: badgers, bobcats, lynx, and river otters; large: coyotes, wolves, and beavers) during best management practices trap testing in the United States, 1997–2018. Error bars represent 95% confidence intervals.

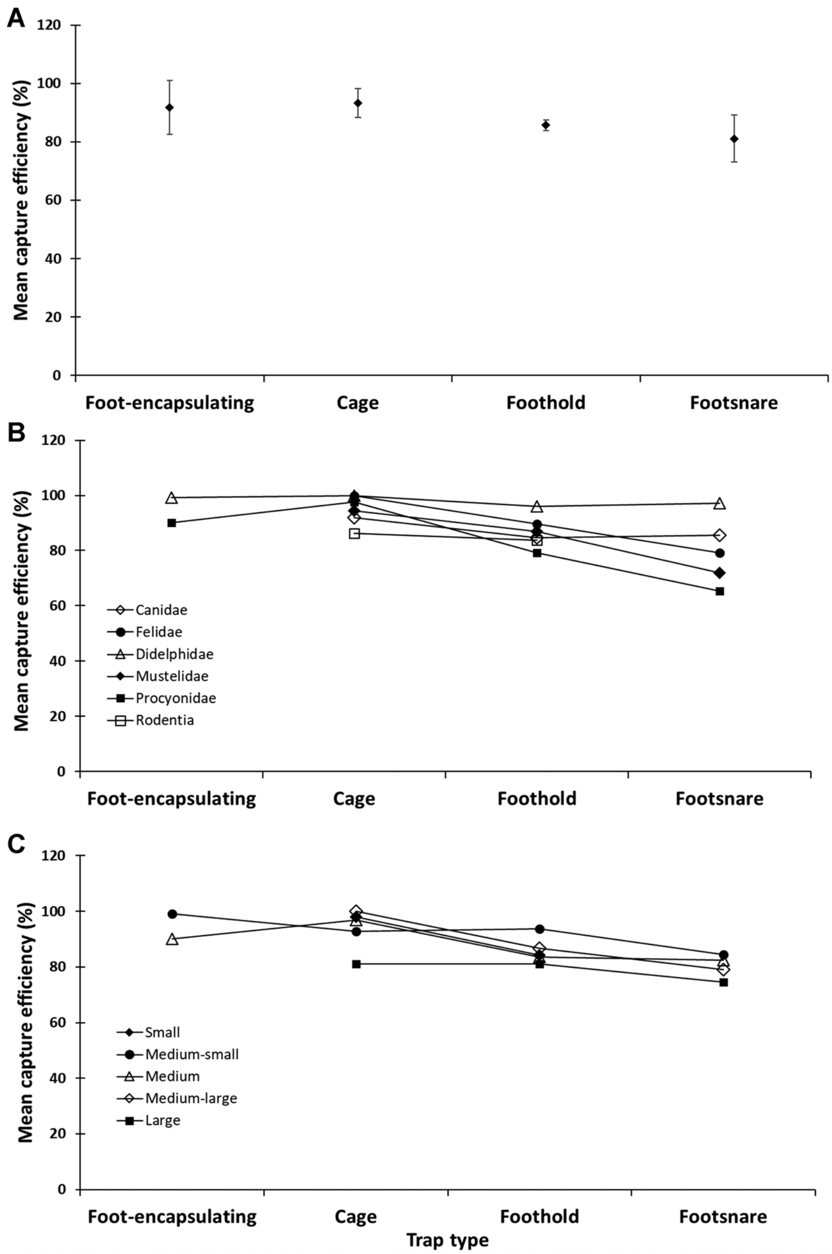

Figure 32. Average capture efficiency by trap type for all species pooled (A), by taxonomic group (B), and by body-size class (C) during best management practices trap testing in the United States, 1997–2018. Error bars in top graph represent 95% confidence intervals. Connecting lines in B and C are used only to facilitate comparison of patterns among groups.

results, therefore, describe the performance of traps deployed under variable biotic and abiotic conditions by experienced trappers. To help ensure our results will be broadly applicable predictors of trap performance, trapper education programs are critical, especially for new trappers. In the United States, trapper education programs were offered, as of 2015, in approximately 70% of states (AFWA 2016), though not all are mandatory. We also developed a national trapper education program (AFWA 2018) that is available to anyone and incorporates key BMP principles and findings. We encourage all states to implement trapper education courses, incorporate key BMP findings in those programs, and consider mentoring programs for beginning trappers. We also recommend that all students and research biologists involved in the live capture of furbearers receive training and consult our data and online trapping BMPs (AFWA 2017*a*) before initiating fieldwork; soliciting advice from experienced trappers is also highly encouraged.

Continuing innovation by trappers and trap manufacturers, ongoing trapper education efforts, and collaborative research between trappers and wildlife managers will lead to further improvements in animal welfare and trap selectivity and efficiency. Foot-encapsulating traps are but one recent example; they were developed by avocational trappers, confirmed through collaborative research to be efficient and highly selective for raccoons (and Virginia opossums) and to have notably lower injury scores than most traditional foothold traps, and now are

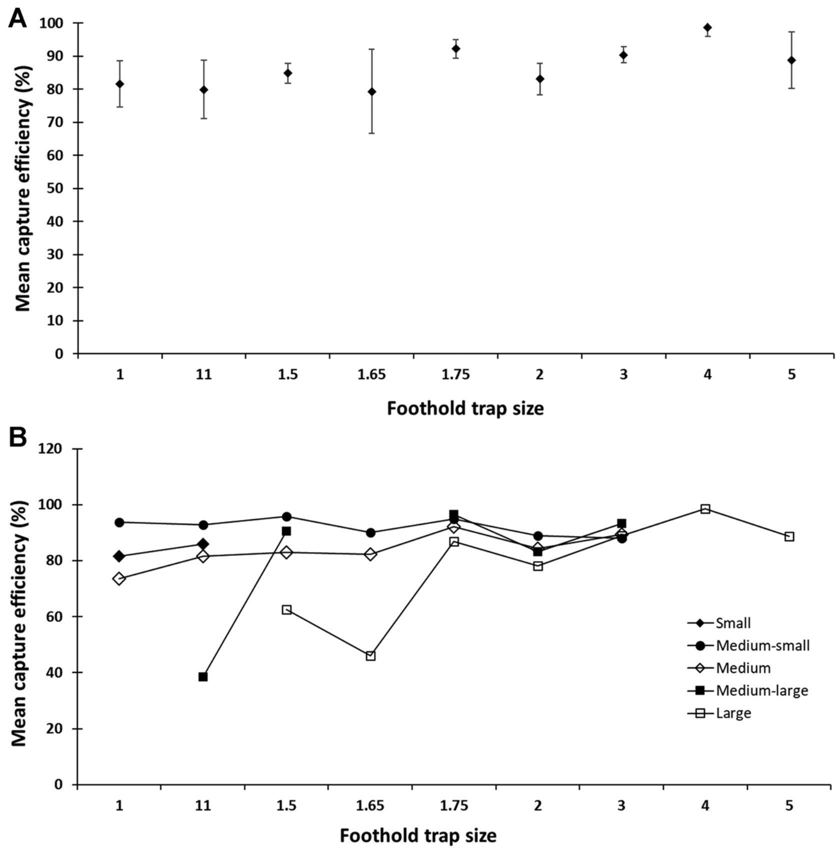

Figure 33. Average capture efficiency by foothold trap size for all species pooled (A) and by body-size class (B) during best management practices trap testing in the United States, 1997–2018. Error bars in top graph represent 95% confidence intervals. Trap sizes are based on the common nomenclature used by trap manufacturers. Although this nomenclature is typically associated with trap jaw spreads, it is not an actual measurement in itself. Connecting lines in B are used only to facilitate comparison of patterns among groups.

the most commonly used traps for raccoons in the United States (Responsive Management 2015).

We recognize there will be continuing debate about what constitutes appropriate welfare thresholds for animals captured in traps, but our use of an internationally accepted (ISO) injury scoring system and both cumulative and maximum injury thresholds provided a practical and appropriate way to assess and discriminate traps, and should ultimately improve the welfare of animals captured in restraining traps. We concluded 40% of the trap-species combinations that we evaluated failed BMP standards. Our numeric thresholds were intended for use in development of broad trapping BMPs, and we recognize there may be situations (e.g., capture of animals in pressing human health and safety situations, certain wildlife research projects) where higher or lower standards (i.e., welfare thresholds or trap-selection criteria) may be necessary or desired.

Although it may have been possible to collect additional information as an index of pain or distress (e.g., use of cameras to document animal behavior in traps, collection of blood for quantifying stress hormones), we did not for several reasons. First, our primary focus was to collect data specifically on trap-related injuries; injury severity scores have been shown to be reliable predictors of mortality risk in humans (Baker et al. 1974, Copes et al. 1988), and effects of injury on survival were a key consideration in our criteria development. Second, pain perception is a complex and subjective process (Katz and Melzack 1999), but we felt that it was reasonable to assume that injury scores would be positively, even if weakly, correlated with pain and distress. Finally, we, and the ISO process (ISO 1999*b*: Annex A, Scope 1, paragraph 1.2), concluded that translating observed behavior or hormone profiles into metrics with associated welfare thresholds seemed an intractable approach. For example, distinguishing stress associated directly with a specific trap injury (i.e., our primary focus) is confounded by stress associated with the presence of humans at the site to dispatch or release the animal, or possibly from agitation caused by other animals visiting the site. Our collective experience on numerous capture-related projects, along with published studies by others (Kreeger et al. 1990, Marks et al. 2004), clearly shows that although variable across individuals and species, captured animals often undergo a cycle of behavior from initial agitation upon capture to comparative inactivity, and then agitation when humans or other animals arrive at the site. Averaging or interpreting hormone metrics or behavior across the full time of capture did not seem possible with our long-term and large-scale effort. As with BMPs for any activity, they are intended to be living documents that incorporate both scientific and practical considerations. If future evidence suggests more appropriate thresholds or alternative field-practical metrics, our BMPs can be revised.

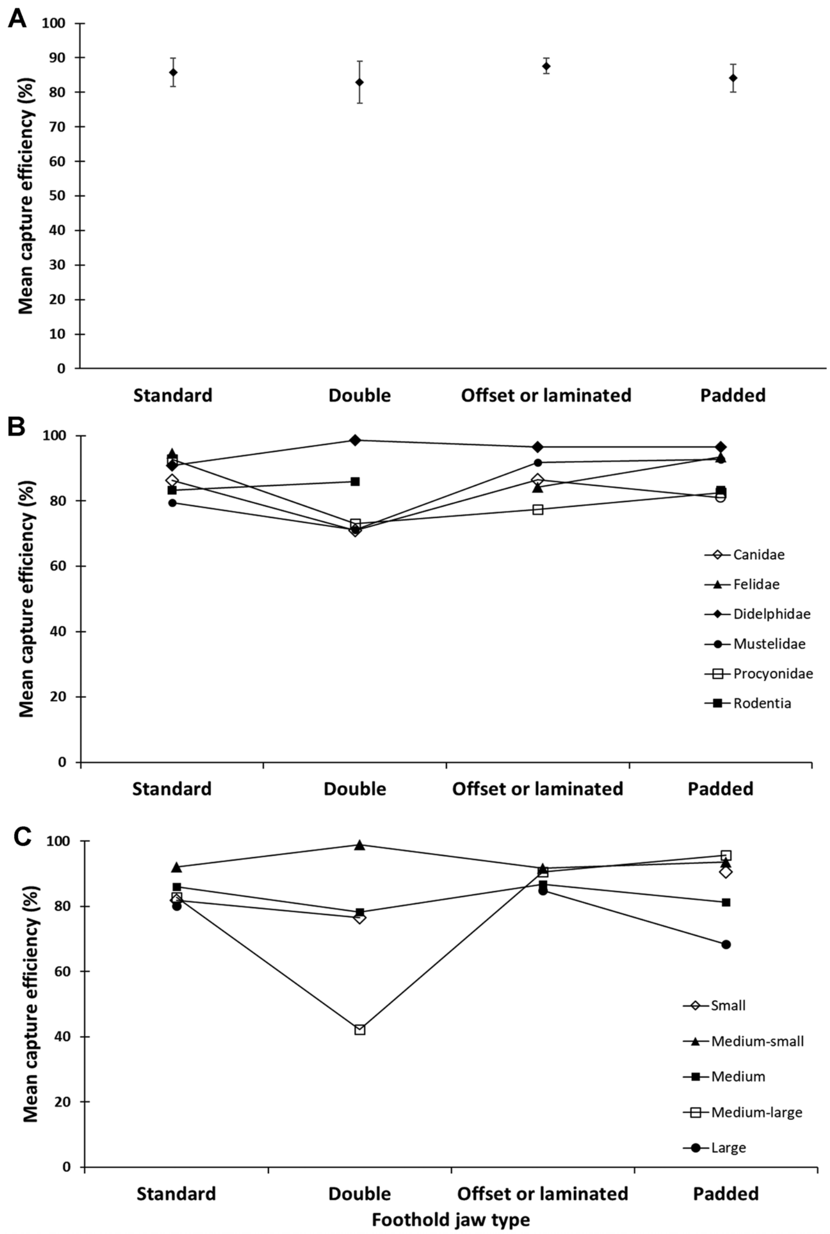

Figure 34. Average capture efficiency by foothold jaw type for species pooled (A), by taxonomic group (B), and by body-size class (C), during best management practices trap testing in the United States, 1997–2018. Error bars in top graph represent 95% confidence intervals. Connecting lines in B and C are used only to facilitate comparison of patterns among groups.

In the BMP process, we did not opt to use confidence interval overlap or other statistical testing to evaluate a trap against the thresholds, or against other traps. We acknowledge that we or others could do so, using, for example, bootstrapped confidence intervals for the mean or median, but doing so has 2-sided effects. Specifically, an injury mean below the threshold (i.e., passing BMP criteria) but with an upper confidence limit extending above the threshold would fail, whereas an injury mean above the threshold (i.e., failing BMP criteria) but with a lower confidence interval extending below the threshold would pass. A conservative approach might suggest doing only the former, and our use of the mean for a threshold, on what is often positively (right) skewed data, is effectively such a conservative approach; in 87% of the 231 trap-species combinations, the mean injury score for a trap was greater than the median.

For several reasons, we do not view BMPs or our data as tools for identifying only 1 best trap that should always be used for a given species. Best management practices are designed to offer users multiple approved options that meet minimum performance thresholds, and are most likely to be accepted when they offer this flexibility. Furthermore, there are often tradeoffs when selecting a trap, such as between welfare, efficiency, selectivity, and practicality; the social acceptability of various tradeoffs will be context-specific. For example, a more humane but slightly less efficient trap may be the prudent choice on a wildlife research project, but a less humane but more efficient trap may be the prudent choice in situations involving time-sensitive

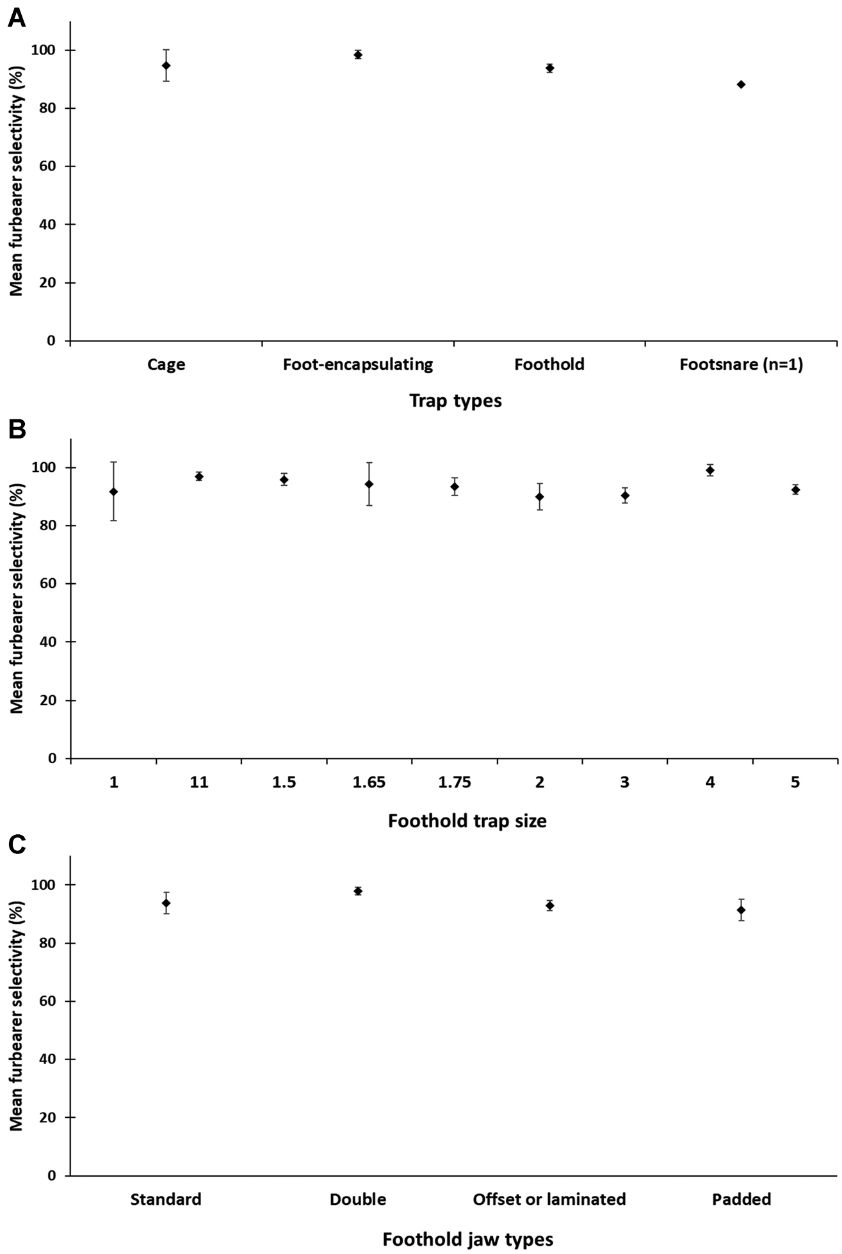

Figure 35. Average furbearer selectivity by trap type (A), foothold trap size (B), and foothold jaw type (C) during best managemen practices trap testing in the United States, 1997–2018. Error bars represent 95% confidence intervals. Trap sizes are based on the common nomenclature used by trap manufacturers. Although this nomenclature is typically associated with trap jaw spreads, it is not an actual measurement in itself.

protection of human property or health. If all other trap use considerations (i.e., efficiency, selectivity, practicality, and user safety) are essentially identical for multiple traps being considered in a given context, we certainly recommend trap users deploy a BMP-compliant trap with lower injury scores.

We used daily trap checks to standardize testing because 1) they are required for live-restraining traps in approximately 70% of states (AFWA 2016), and 2) testing multiple protocols was not feasible on this large-scale effort. It is reasonable to assume that average time spent in a trap increases with trap-check interval. It may also be tempting to assume that average injury scores are positively correlated with the time spent in a trap, but data are extremely limited. Based on observed restraint behavior described above, injury occurrence might be most likely in the first hours after capture, and again when humans approach to dispatch or release the animal (which would occur regardless of trap-check interval), although it may not be appropriate to assume animal movement is required to cause trap-related injury. We are unaware of observations of restraint behavior beyond a 24-hour period. Proulx et al. (1993) compared raccoon injuries after 12 and 24 hours in 2 trap models, and reported that the mean injury score was higher after 24 hours compared to 12 hours in 1 trap but lower in the other trap; they did not conduct statistical tests, but neither likely represented a significant difference. Furthermore, trap-check interval does not equate with time spent in a trap; with a 48-hour trap check requirement, a captured animal could still have been in a trap for only 6 hours prior to trap inspection. For example, in research unrelated to our BMP process, Proulx et al. (1994) documented that even on 1 Arctic fox trapline where traps were checked on average every 8 days, 28% of captured foxes had no injury, including edema; presumably, the foxes with no injury were captured later in the trap-check interval. The relationship between trap-check intervals and average time spent in a trap is likely temporally and spatially variable. Factors such as animal density or home range size, trap density (Wilson et al. 2011), and biotic (e.g., food availability; Jensen et al. 2012) and abiotic (e.g., temperature; Martin et al. 2017) conditions influence animal presence, activity, and vulnerability to capture at a given location. It is highly unlikely that a trap set on the landscape in one state or region has the same daily probability of catching an individual of a given species as it does in another state or region. Therefore, we caution against generalizations regarding the effect that extended trap-check intervals have on injury scores, especially when projecting across states in different regions of the country. Conversely, we also stress that our trap performance results are contingent on the daily trap-check interval used in this study and should not be assumed to apply to other intervals; additional research would be needed to test such an assumption. Ultimately, the local situation (e.g., purpose for trapping, weather conditions, land access, selectivity concerns, animal density) and societal desires will influence the need for, and practicality or feasibility of, daily trap checks.

A key focus of this publication is to present the species-specific summaries of the systematic data we collected on trap injury scores, efficiency, and selectivity. Our results have many potential species-specific applications, in addition to their use in developing BMPs. We previously summarized past species-specific trap research (IAFWA 1997), and some additional trap research (outside of our effort) has taken place since that time. However, we refrain from detailed species-specific discussion or comparison of our findings to past research because 1) our species-specific figures and tables are self-explanatory, and 2) our research used different (ISO-based) methodology for assessing trap performance than most previous research. We focus our remaining discussion on broad patterns in the totality of our data.

Injury scores

We relied on experienced trappers for capturing animals, but we tested most traps using multiple trappers in multiple states. Undoubtedly, there was variation in their specific trap sets, baits, lures, and environmental conditions. Yet for the 21 trap-species combinations with sufficient sample sizes in >1 state, we rarely ($n = 2$) observed statistically significant (i.e., $P < 0.05$) geographic differences in mean injury scores (Fig. 22). Our trap-specific injury scores for each species should be reliable predictors of injury in a variety of situations, provided similar methods are employed (i.e., ISO injury scoring, daily trap checks). We do not know if the 2 significant differences we did observe are meaningful or a result of sampling error, but the collective results suggest that trap mechanical attributes are a more important predictor of trap-related injuries than trap set variation or varying environmental conditions.

Our results do suggest that taxonomic affiliation may correlate with trap injury scores, presumably via anatomical or behavioral traits. Noting that our data on felids are limited to 2 species, and primarily bobcats, average injury scores for felids were significantly lower in all trap types (Fig. 23). We postulate this to be the case for 2 reasons: 1) felids may have evolved strong yet flexible and shock-absorbing feet and forelimbs, useful for jumping from elevated locations or pouncing on or grasping prey (Meachen-Samuels and Van Valkenburgh 2009, Kitchener et al. 2010, Cuff et al. 2016); and 2) our collective experience suggests that felids are more passive or secretive during restraint, perhaps associated with their stalking (not cursorial) tendencies (Kitchener et al. 2010), which may further reduce potential for lunging-related injury. These attributes make injuries less likely, either directly from the trap or from struggling to escape the trap.

Taxonomy may also be correlated with the tendency towards self-directed biting when in a live-restraining trap. Although self-directed biting was rare (<2%) for most species (Fig. 29), it was comparatively high for skunks (39%) and raccoons (22%), with 2 of the 3 species with the next highest values (i.e., otter, 6.8%; badger, 4.0%) potentially having a closer phylogenetic link to skunks or raccoons. For example, many previous classification efforts have concluded that skunks, otters, and badgers may be in a clade separate from other mustelids (Bryant et al. 1993). More recent phylogenetic work suggested that skunks may be more related to raccoons (i.e., the 2 species in which we observed the highest degree of self-directed biting) than they are to mustelids (Sato et al. 2012). Although taxonomic debates may continue, it does appear that phylogeny may be correlated with this trap-response behavior. The underlying mechanisms are unclear and likely multivariate, but as appears true for raccoons (Kaufman 1982, Whiteside 2009), we suspect one potential contributor may be that these species may have comparatively reduced cushion and high innervation in their forefeet, useful (depending on species) for digging, climbing, or detecting or handling prey. This may increase negative sensory feedback and produce a more aversive or aggressive response to capture in foot-restraining devices. It remains unclear whether there is also a purely psychological component to self-directed biting, perhaps stemming from confinement in any trap, but our data provide minimal support for this; in cage traps, no skunks and only 1 raccoon exhibited this behavior. Data from Proulx et al. (1993) also suggest that time spent in a trap may play only a minor role in self-directed biting in raccoons; comparing a foot-encapsulating and a padded-jaw foothold trap, they found no evidence of self-directed biting in either trap after 12 hours and evidence in only 1 animal (in the padded-jaw trap) after 24 hours. Foot-encapsulating traps substantially reduced (from 27% to 2%) self-directed biting in raccoons compared to other foot-restraining trap types, but they are not currently effective capture devices on striped skunks for which self-directed biting was most common. Although we opted to describe these injuries as self-directed biting, we note that it remains unknown whether an animal is intentionally directing this behavior towards itself, or towards the trap but with injury indirectly occurring to a potentially desensitized foot (e.g., from reduced circulation). Furthermore, we recorded self-directed biting as a binary event, but its actual translation to injury can be variable; although we detected a statistically significant positive correlation between incidence of self-directed biting and injury scores, the correlation was not particularly strong (i.e., $r < 0.5$).

Across species, mean injury scores generally exhibited an inverse correlation with body size (Fig. 24), despite trap size also typically changing in accordance with animal body size (i.e., trappers typically use, and we evaluated, larger traps on larger species). Although it remains possible that changes in trap jaw spreads do not change proportionately with other relevant trap metrics (e.g., clamping force), our finding suggests that smaller species are, on average, more prone to trap injury, whether for anatomical, physiological, or behavioral reasons. Biewener (1982) found that the material strength (per unit area) of animal bone does not vary with body size. However, Biewener (1989) also found that the force-generating ability of muscle, after normalizing for body weight, decreases in larger animals, suggesting that smaller animals may be more capable of causing injury to themselves from lunging or struggling while in a trap. This might explain, for example, the poor performance of even a very small padded-jaw foothold trap on swift foxes; injury scores were affected by the prevalence of major skeletal muscle degeneration (77% of animals) that occurred primarily to the deltoid, soleus, and gastrocnemius muscles, likely a result of lunging during restraint and not the trap per se. A potential force-based predisposition to injury might be exacerbated by a tendency, based on our observations, for some smaller species to more vigorously or continuously attempt escape from restraint, perhaps a result of their increased vulnerability to predation or interspecific killing (Palomares and Caro 1999), or their higher relative metabolic rates (White and Seymour 2003) that may require proportionately more activity and food acquisition, particularly for carnivores (Elgar and Harvey 1987). If correct, this suggests that certain trap-related modifications (e.g., shorter, heavier, or shock-absorbing trap chaining systems) and trap set locations (e.g., in more security cover) may play an important role in reducing injuries in smaller species. However, during our swift and kit fox testing, even a very small foothold trap (number 1 coil-spring) equipped with padded jaws, a short chain, and a shock spring still failed BMP injury thresholds; we do not have comparative data (i.e., same trap with a longer chain or without a shock spring) to confirm if the features of the trap we tested did at least reduce injury. We recommend additional species-specific testing to assess whether more shock-absorbent springs or staking systems, or setting traps in or near more concealment cover, might reduce injury levels in smaller species.

We did not attempt to isolate and compare the effects of some trap sub-components, such as chain length and swiveling, on injury. The only exception was a specific comparison we conducted evaluating the influence of freedom of movement (i.e., chain length; 15 vs. 76 cm) on frequency of self-directed biting in raccoons, and we detected no appreciable effect on this behavior. For coyotes, past research (Linhart et al. 1981, 1988) has provided conflicting results on the effect of chain length on injury. Long chains may increase lunging-related injury, but short chains may cause agitation from more confined animal movement, which Houben et al. (1993) hypothesized may lead to more persistent attempts to escape or a more aggressive response to the trap. They suggested that moderate length (45 cm) chains might be preferred for coyotes, but more research is needed to assess the effects of chain length on injury scores and we suspect optimal lengths are dependent on other trap attributes (e.g., jaw type, thickness) and species-specific behavior and morphology. The length of chains attached to the vast majority of traps we tested were ≤45 cm, many ≤30 cm (AFWA 2017*a*). Houben et al. (1993) also posited that appropriate trap swiveling is critical to reduce torsion-related injury when restrained animals twist or roll, a recommendation supported by our observations and conventional wisdom amongst avocational trappers. All foot-restraining traps we tested contained ≥2 swivel points, often ≥4, in the trap chaining system, and we recommend this on most traps.

Across species, cage traps consistently produced the lowest injury scores (Fig. 25), though not always appreciably better than the foot-restraining trap with the lowest injury score (i.e., for Arctic and gray foxes). Most animals experienced some injury in cage traps, often tooth damage. We have not yet evaluated a cage trap on river otters, and Shirley et al. (1983) were unable to capture otters in a double-door cage trap. Blundell et al. (1999) compared Hancock cage traps (clam-shell design) to number 11 double-longspring traps with double jaws for otters and found no differences between trap models in injuries to appendages, but Hancock cage traps resulted in more serious tooth injuries; they recommended the number 11 double-longspring with double jaws to minimize the potentially more influential tooth injuries to captured river otters.

We also have yet to evaluate cage traps for badgers, Canada lynx, American marten, nutria, American mink, red foxes, coyotes, and wolves because of efficiency concerns or their infrequent use by avocational or nuisance control trappers. Based on their common use by researchers on American martens and Canada lynx, we presume injury scores and efficiency are generally acceptable for these species, though formal ISO-based testing is needed to confirm whether they pass BMP thresholds. In multi-trap comparisons of injuries, both Mowat et al. (1994) and Kolbe et al. (2003) found no or minimal injuries to lynx in cage traps. Cage traps have also been used for nutria (Robicheaux and Linscombe 1978, Baker and Clarke 1988), and the low injury scores we observed with cage traps for beavers (also see Koenen et al. 2005) and muskrats suggest similar low-injury potential on nutria. Although cage traps might also produce few injuries in larger canids, we did not conduct any such testing and have notable concerns with respect to efficiency on these species (see efficiency discussion below). Furthermore, where BMP-approved alternatives to cage traps exist, as is the case for many furbearing species, other restraining trap types may be preferable in many situations because of reduced costs and fewer practical constraints (e.g., reduced size and weight). However, for some species where testing of foothold traps as restraining devices has been absent or limited (e.g., fishers, martens, minks, ringtails, weasels) or not promising (e.g., muskrats, skunks, swift and kit foxes), cage traps may be the preferred method for live restraint at this time, and may remain so for some smaller species. Killing traps are also highly effective for many of these species, many such devices meet BMP standards, and avocational trappers usually prefer them for many of these species (Responsive Management 2015).

A consistent conclusion from previous raccoon and striped skunk trap research has been that most serious injuries observed were due to self-directed biting (Berchielli and Tullar 1980, Novak 1981, Nettles et al. 1990, Proulx et al. 1993, Hubert et al. 1996). Furthermore, many have concluded that padded-jaw foothold traps are not likely to appreciably reduce injury scores for these species (Tullar 1984, Olsen et al. 1988, Nettles et al. 1990, Hubert et al. 1991, Kern et al. 1994, Kamler et al. 2000). They may also have lower efficiency for raccoons (Linscombe and Wright 1988, Hubert et al. 1991, this study; but see Saunders et al. [1988] and Heydon et al. [1993] for contradicting results). We found, as others (Proulx et al. 1993, Hubert et al. 1996) have, that foot-encapsulating traps, highly selective for raccoons and Virginia opossums, were very effective at reducing injuries in raccoons associated with self-directed biting, and BMP welfare criteria were met for 6 of the 9 models we tested. Similar to cage traps, however, tooth damage was common and future design improvements to reduce edges on foot-encapsulating traps may address this particular injury. Foot-encapsulating traps are now the most commonly used capture device by avocational trappers in the United States when targeting raccoons, and second-most common (after cage traps) when targeting Virginia opossums (Responsive Management 2015).

A power-activated footsnare passed BMP standards for bobcats, Canada lynx, coyotes, gray foxes, raccoons, and red foxes, but failed injury thresholds for Virginia opossums; injury results were also poor for striped skunks, but sample size was below that required for BMP assessment. Past research, primarily on canids, has produced variable conclusions regarding footsnare injury levels in comparison to other trap types, perhaps owing to different footsnare models tested (Berchielli and Tullar 1980, Onderka et al. 1990, Shivek et al. 2000). We have not evaluated footsnares on Arctic foxes or badgers, 2 species for which footsnares may have potential value. We are not at liberty to publish the numeric results, but a larger footsnare has passed United States BMP standards for gray wolves based on testing conducted by Canada. For species on which the footsnare passed BMP standards, injury scores were typically similar to foothold traps that also passed BMP standards.

There has been much discussion and research on the effect of foothold jaw types on injury. Pooling species, our data indicate that compared to standard-jaw traps, double-jaw models, which we tested on gray foxes, muskrats, river otters, raccoons, nutria, striped skunks, and Virginia opossums, do not generally reduce injury scores (Fig. 26). This may be due to the lower jaw on these traps often being inset from the main jaw, which may not contact the foot. Because pressure is proportional to force (i.e., dependent on surface area), a second inset jaw may not effectively reduce pressure and compression-related injury potential; single but wider-faced jaws do often appear to reduce injury (Kern et al. 1994, Phillips et al. 1996, Hubert et al. 1997). We did find that double-jaw traps, on average, reduce the incidence of self-directed biting in raccoons. However, unlike fully enclosed foot-encapsulating devices, some double-jaw foothold traps may not provide a sufficient barrier against self-directed biting, possibly a result of their secondary jaws being inadequately spaced. We also found that padded and offset or laminated jaws, both tested on most medium and large species, do, on average, reduce injury scores compared to standard jaws. These effects generally held across the taxonomic and body-size groupings we examined. However, the advantages of modified-jaw foothold traps were more evident for some species. American badgers and bobcats, for example, had BMP-compliant animal welfare scores for a wide range of foothold jaw types, whereas only padded-jaw foothold traps currently meet standards for fishers and nutria.

Padded-jaw traps have been studied on a wide array of species, including badgers (Goodrich 1991, Kern et al. 1994), bobcats (Olsen et al. 1988, Earle et al. 1996, Kamler et al. 2000), coyotes (Linhart et al. 1988, Olsen et al. 1988, Onderka et al. 1990, Phillips et al. 1992, Phillips and Mullis 1996), gray foxes (Olsen et al. 1988), muskrats (McConnell et al. 1985), Virginia opossums (Nettles et al. 1990), raccoons (Tullar 1984, Olsen et al. 1988, Nettles et al. 1990, Hubert et al. 1991, 1996; Kern et al. 1994), red foxes (Olsen et al. 1988, Kreeger et al. 1990, Onderka et al. 1990, Kern et al. 1994, Kamler et al. 2000), river otters (Serfass et al. 1996), striped skunks (Nettles et al. 1990), and wolves (Frame and Meier 2007, Turnbull et al. 2013). Many, but not all, of these studies have reported fewer injuries in padded-jaw traps. In our study, offset or laminated jaws performed as well as padded jaws for many species. In at least 3 previous red fox or coyote studies (Kern et al. 1994, Phillips et al. 1996, Hubert et al. 1997), use of foothold traps with laminated jaws resulted in fewer injuries than standard-jaw foothold traps, and Houben et al. (1993) found no difference in mean injury scores for coyotes captured in a padded-jaw versus laminated offset-jaw number 3 coil-spring. Laminated- or offset-jaw models may be preferable to avocational trappers because they are easier to prepare and require less maintenance than padded-jaw traps (i.e., no periodic replacement of worn pads). Furthermore, there were indications that padded-jaw traps, averaged across all trap sizes tested, performed worse than many non-padded traps for striped skunks and raccoons. We speculate this may be due to the soft flexible pads either being targeted for biting, or potentially numbing the foot (i.e., reduced circulation); either may result in biting injury on the foot. Reduced circulation may also explain the increased risk with padded-jaw traps of lynx toes freezing in cold temperatures (Kolbe et al. 2003). Nonetheless, even where injury in offset or laminated traps may be similar or slightly less for a species, padded-jaw models may be preferable when simultaneously trapping multiple species, one for which padded jaws clearly performed better.

Not surprisingly (because larger traps are typically used on larger species), we did not find a positive correlation between foothold trap size and injury scores when pooling all species (Fig. 27). We did detect positive correlations between foothold trap size and injury scores within some species or groups (Fig. 28), but there were no consistent patterns across species or jaw types; broad generalizations about increased injury resulting from larger traps are not appropriate. This may be a result of variations in species-specific morphology or trap-response behavior, or because trap size may be a poor correlate of other underlying trap attributes (e.g., velocity and clamping force) that affect injury levels. Stronger velocity or clamping force has the potential to increase impact- or compression-related injury but also the potential to reduce lacerations or bone abrasion by preventing the foot from moving side-to-side across the trap jaws. Data from Houben et al. (1993) and Gruver et al. (1996)

indicate that number 3 padded-jaw traps with 4 coil-springs (i.e., greater clamping force) resulted in fewer injuries to coyotes than the same model with the original 2 coil-springs, and Kuehn et al. (1986) detected fewer wolf injuries in traps with offset jaws and rounded teeth, which may prevent side-to-side foot movement. Additional research is needed to determine optimal species-specific trap velocities and clamping forces, which we believe are those that are minimally sufficient to capture and hold an animal and prevent the foot from easily sliding between the trap jaws; levels below this may cause lacerations or bone abrasions from foot movement or not yield acceptable trap efficiency, and levels above this may increase risk of impact or compression injury. Optimal velocity and clamping force may also vary with foothold jaw design, specifically jaw thickness (i.e., force displacing area) and jaw shape (e.g., square vs. round edges) or hardness (e.g., pads vs. no pads).

Trap size (jaw spread) may also play an independent role in injury levels through its influence on foot strike location. However, foot strike location is a complex function of factors including body stance (i.e., plantigrade vs. digitigrade), foot size in relation to jaw spread, trap pan tension in relation to body weight, and speed of reflexive response to a trap being sprung. We are unaware of published data on which to base recommendations, but our experience along with conventional wisdom among trappers with whom we have worked, is that optimal strike locations are those across the middle portion of the foot and over or in contact with the foot pad, not those near or above the ankle or that only restrain the animal by a subset of toes. Trap pan-tension devices (or adjustments) are important components that can play a role in controlling strike locations for a given trap size and species, but more research is needed to assess the consistency of this approach.

Although foothold-style traps are often practical and efficient tools, injury data for muskrats, striped skunks, and swift or kit foxes, or lack thereof for weasels, minks, wolverines, and martens, currently precludes inclusion of any such devices in BMPs for use in live-restraining situations. For muskrats, martens, and weasels, avocational trappers almost exclusively use lethal traps and sets (Responsive Management 2015), and several such traps or trapping systems meet BMP criteria for these species (AFWA 2017*a*). The BMP-compliant cage or killing-style traps are also the most commonly used devices used by avocational trappers targeting striped skunks (Responsive Management 2015). Our ongoing testing of the use of cable restraints to live restrain furbearers suggests low injury scores for several species (e.g., beavers, red foxes, coyotes; also see Gese et al. 2019 for wolves) and may be another viable live-restraining trap for species such as gray, kit, and swift foxes, striped skunks, bobcats, and raccoons.

Efficiency

As defined and measured in our study, capture efficiency (capture rate according to ISO [1999*b*]) can be influenced by trap-specific mechanical attributes, local abiotic conditions, and trapper experience and deployment methods (Pawlina and Proulx 1999, Ruette et al. 2003). This likely explains the largely consistent (across taxonomic and body-size groupings) decrease in efficiency we observed from cage traps to footholds to footsnares (Fig. 32). Cage traps have simpler mechanical attributes, are less influenced by abiotic conditions (i.e., not buried in the ground like foothold traps and footsnares), and require less user skill or experience to set them. However, cage trap design can vary and influence efficiency. Lacki et al. (1990) evaluated efficiency (captures/trap night) of 2 models of cage traps on muskrats and concluded that cage traps with spring-loaded doors were more efficient than those with gravity-operated doors. Mowat et al. (1994) observed low lynx efficiency in a commercial cage trap and recommended against their use for practical or logistical reasons; Kolbe et al. (2003) had much higher lynx capture efficiency in a custom-made cage trap.

These typical factors likely to influence efficiency may also explain why footsnares had the lowest average efficiency; footsnares have numerous mechanical components, are usually concealed in dirt and are influenced by abiotic conditions, and few trappers have extensive experience with them (Responsive Management 2015). Previous research has also found comparatively low efficiency in footsnares (Berchielli and Tullar 1980, Novak 1981, Skinner and Todd 1990). Compared to cage traps and footsnares, foothold traps we tested had intermediate efficiency; they have an intermediate number of mechanical components, are more influenced by abiotic conditions than cage traps, and generally require less skill to set than footsnares and trappers are more experienced with them. Despite the variability we observed in capture efficiency, it was high ($\bar{x}$ = 86%) for most trap types, few devices failed our BMP efficiency criterion, and we did not observe differences across animal body-size classes when pooling trap types.

We did observe a 12 percentage point reduction (88% to 76%) in mean capture efficiency for traps deployed exclusively in aquatic compared to terrestrial sets. However, much of this is attributable to lower efficiency with foothold traps set for live restraining river otters. We believe this is a result of the increased speed of movement and sliding tendencies that river otters exhibit near typical otter trap set locations (i.e., entering and exiting the water), resulting in more sprung traps without a capture. Furthermore, foothold traps we tested on otters, all of which passed BMP welfare criteria, were smaller models that have commonly been used by biologists for research and reintroductions (Shirley et al. 1983, Serfass et al. 1996, Blundell et al. 1999); avocational trappers primarily use killing traps or sets (Responsive Management 2015).

Traps may change in design over time in response to efficiency concerns from trappers, leading to temporally variable results. For example, the Victor (now, Oneida Victor) Soft Catch™ coil-spring trap went through multiple generations of improvements to address concerns related to poor efficiency and durability (Linhart et al. 1986, Linscombe and Wright 1988, Linhart and Dasch 1992, Phillips and Mullis 1996, Tuovila et al. 1996, Earle et al. 2003). Training to properly set and use this particular trap may improve its efficacy (Linhart and Dasch 1992), including use of more pan tension, ensuring the trap dog (Fig. 2) does not cause the rubber pad to roll on to itself, and elevating the free trap jaw slightly. Using experienced trappers and current trap models, foothold jaw type had no consistent influence on capture efficiency in our study (Fig. 34).

An alternative efficiency metric often used for trap comparisons is captures per trap night (CPTN). Unlike the efficiency metric we used, CPTN is heavily influenced by population density of the focal species. Because our interest was in isolating performance of the trap itself, we did not use CPTN. It is nevertheless relevant and highlights a limitation of our efficiency metric; a trap with high capture efficiency (as we calculated) may still have few CPTN if animals completely avoid engaging with the trap, and for some species this seems more likely to be the case with cage traps. For example, Robicheaux and Linscombe (1978) found that double-door wire-mesh cage traps had the fewest CPTN of all traps they evaluated on nutria and raccoons, and Austin et al. (2004) had fewer raccoon captures in cage traps compared to a foot-encapsulating trap. Furthermore, even if cage traps might meet the BMP efficiency standard (i.e., capture rate given they spring the trap) for medium- and large-sized canids, we are skeptical we could capture enough animals on typical avocational traplines to conduct injury assessments because of their tendency towards complete avoidance of cage traps (i.e., CPTN is likely to be extremely low). Cage traps may be useful for capturing coyotes in urban areas where they are habituated to human structures and activities (Way et al. 2002), but these restraining devices produce few captures in rural areas (Shivik et al. 2005). We did not capture any coyotes in cage traps during our research, including in bobcat-sized cage traps deployed in areas where coyotes were present. Similarly, very low catch success has been reported for cage traps set for red foxes (Muńoz-Igualada et al. 2008; T. L. Hiller, Wildlife Ecology Institute, unpublished data), and we captured only 1 red fox in a cage trap during our research even though they were present in all areas. Accordingly, we urge caution in assuming that the efficiency metric we used, especially when computed for cage traps, will be equally meaningful in all situations or for all species.

Selectivity

Reducing accidental capture of non-target species, be they domestic, threatened, endangered, or otherwise protected species, or other non-furbearing game species, is important to avocational trappers, researchers, and the public alike. Many trap or trap-setting selectivity improvements, including for body-gripping kill traps (AFWA 2017*b*) and snares or cable restraints (AFWA 2009), have been developed and incorporated into trapper education. For foothold, foot-encapsulating, footsnare, and cage traps, common options for affecting selectivity include pan tension controls (Turkowski et al. 1984, Phillips and Gruver 1996), proper selection of trap (or jaw-offset) size to capture or avoid a specific species, and education on more selective set locations and bait or lure choices. We recommend pan tension devices or adjustments be incorporated into medium and large foothold traps as an effective way (Turkowski et al. 1984) to minimize capture of smaller animals, especially when the smaller animals present are not legally harvestable or the trap has not met BMP standards for that species. We also encourage targeted research to ascertain optimal species-specific pan tension for maximizing both efficiency and selectivity.

Avocational trappers commonly set traps targeting multiple legal furbearing species, and some are typically caught only while pursuing other species (e.g., few trappers target striped skunks or Virginia opossums); our research was designed to mimic these realities. In addition, to increase project efficiency we opted to collect and necropsy all legal furbearing animals captured on a project, especially in the early years of our research. Our selectivity metric is therefore trap-specific, not species-specific, and represents the proportion of total captures that were legal furbearers across all testing projects where a given trap model was used. Similar to efficiency, furbearer selectivity for a given trap will vary temporally and spatially, in this case related to factors such as species diversity (furbearers and non-furbearers), relative abundance, and user-controlled variables (e.g., set type, set location, bait and lure choices). However, given the wide geographical area over which we tested most traps, with multiple trappers using varied methods, those contemplating multiple trap choice options can expect furbearer selectivity results to fall within our observed trap-specific confidence intervals, provided those deploying the traps are reasonably experienced and trapping in rural or semi-rural landscapes where our data were derived (i.e., avocational traplines).

Although other studies have reported comparatively low species-specific selectivity in cage traps (Way et al. 2002, Shivik et al. 2005, Muńoz-Igualada et al. 2008), in our study they were nearly identical to foothold traps in furbearer (not species-specific) selectivity (94%). This is perhaps unsurprising given that the majority of non-furbearer species captured were feral or free-ranging cats, lagomorphs, birds, and squirrels, all of which are of the size capable, depending on pan-tension controls, of being captured in both cage and foothold traps. Only for medium- to large-sized dogs would captures in commonly used cage traps be less likely than in foothold traps. Foothold trap size also did not have a notable influence on furbearer selectivity (Fig. 35). With the exception of the smallest model of foothold trap we tested (i.e., number 1 or 11, which represented only 15% of the models tested), most devices we examined were of a size capable (depending on pan-tension controls) of restraining the most common non-furbearers captured in our study. We also did not find any notable difference in furbearer selectivity for trap models deployed only on land versus those set in water, or both land and water, and average furbearer selectivity was >93% in all 3 groupings. The most common non-furbearer species captured (i.e., cats, lagomorphs, dogs, birds, squirrels) were similar across these set location groupings. We believe this is because most live-restraining traps set in aquatic areas (i.e., for muskrat, nutria, river otter, beaver, mink, and raccoon) are usually set at the land-water interface in very shallow water, areas that terrestrial non-furbearer species will still investigate, and areas that can temporarily be exposed because of drops in water level. Although the species of non-furbearers captured were similar, birds represented a greater proportion of non-furbearer captures in aquatic sets compared to the overall dataset (22% vs. 13%). Risk of waterbird captures in aquatic trap sets is greater in spring (Bailey 1976, Gross et al. 2017), particularly during spring muskrat trapping, than in fall-winter when most trapping on our project occurred. Nevertheless, bird exclusion devices have been shown to be effective in certain sets during both spring and fall muskrat trapping (Gross et al. 2017).

Although high selectivity is desirable for any trap type, it can be comparatively less important in live-restraining traps because of the ability to release animals. We observed mortality associated with what we deemed to be capture-related stress or injury in 4 furbearer species (i.e., beavers, muskrats, raccoons, and gray foxes), representing 0.5% of the 8,566 furbearers we collected for necropsy from 1997–2018. There were 6 additional furbearer deaths (1 bobcat, 1 opossum, and 4 minks) deemed to be from trap-related stress or injury not included because sample size for the trap-species combination in those cases was below that we used for data reporting here (i.e., 8). We acknowledge that death through other mechanisms can occur while an animal is in a trap, such as being shot by humans or attacked by other animals, but this was uncommon during our study and is largely unpreventable. Although we did not pathologically confirm deaths due to hypothermia, observations from our research suggest that it (or accidental drowning) did occur, particularly for raccoons and muskrats captured in traps set in or near water; Nettles et al. (1990) also reported a high percentage of hypothermia-related deaths for raccoons captured in water sets. Particularly during colder times of the year, we urge caution in deploying traps intended for live restraint in areas where animals, especially terrestrial species, can enter water.

Approximately 1.8% of total captures during our 21-year study resulted in mortality of a non-furbearer. We did not pathologically confirm cause of death in these cases, but some were clearly a result of predation and others were likely a result of capture-related stress or injury. Nearly all non-furbearer mortalities were birds, rabbits, and squirrels; 2 feral or free-ranging cats died and no dogs died or were severely injured as a result of capture in live-restraining traps we tested. Combining furbearers and non-furbearers, most capture-related mortalities involved smaller species, and largely herbivores or omnivores. Others have noted that severe capture myopathy appears rare in carnivores (Hartup et al. 1999, McCarthy et al. 2013). Capture-related mortality could occur from injury (e.g., shock) or a result of stress or exertional myopathy. Breed et al. (2019) described capture myopathy as a pathophysiological manifestation of inherent biological stress defenses of an animal failing. Our hypothesis to explain higher trap injury scores in smaller species seems relevant here as well; smaller animals, perhaps especially those more vulnerable to predation, likely exhibit more exertional resistance to restraint, are at more risk of lunging-related injury, and may incur more stress from an inability to escape, all increasing risk of mortality.

In our study, furbearer selectivity was high for all trap types we evaluated, being lowest for footsnares (88%) and highest for foot-encapsulating traps (99%; Fig. 35). In addition, mortality or significant injury was very rare for domestic species, and the most potential for mortality or injury was with smaller non-furbearers. Nonetheless, selectivity is a critical consideration in trap selection and should be emphasized in educational programs for avocational, nuisance control, and research trappers alike. In most applications, but more so when using foot-restraining compared to cage traps, we recommend trap users give equal consideration to animal welfare and selectivity when selecting a trap. Trap users should consider expected injury level or mortality risk to the species they are targeting and those they may potentially capture in that specific location, selecting trap types, sizes, and features (e.g., jaw type, pan tension controls) least likely to cause injury or mortality to that full suite of species. Our data, along with the online trapping BMPs (AFWA 2017*a*) and a BMP trap-search tool (AFWA 2019) we created, can assist with the decision process, and we encourage consultation with experienced trappers regarding tools and methods that can improve selectivity given the suite of species present in the local area where traps are to be deployed.

Virgós et al. (2016) argued that the current ISO measure to quantify selectivity fails to consider the relative abundance of focal and incidental species, and therefore the result is simply proportional capture data. Although they outlined their concerns about the current ISO measure of selectivity, and the potential consequences to endangered species conservation, they also acknowledged the significant effort necessary to address their concerns. During 2 decades of testing across the United States in our study, we did not capture any individuals of federally threatened or endangered species, though we acknowledge such capture does occasionally occur. Our data show that in most potential scenarios, animals captured in restraining traps can be released alive with minimal or no injury. Furthermore, we are unaware of any modern examples where regulated trapping (or accidental take) has been determined to be the cause of species endangerment in the United States, or a substantial future threat. Conversely, traps have regularly been used in modern times for the restoration of species, protection of endangered species, and for many other conservation or societal benefits.

Trapping in its many forms offers clear benefits to individuals, society, and wildlife conservation, but societal concerns remain that can and should be addressed through ongoing research and education. As new data become available through ongoing research, we will periodically update information reported herein and make it available online at the AFWA website.

MANAGEMENT IMPLICATIONS

Our research to develop BMPs for trapping has been the most extensive and intensive mammalian capture evaluation effort ever undertaken. The results have management implications to wildlife and land management agencies, research institutions, avocational trappers, nuisance control businesses, trap manufacturers, and the general public. Best management practices are based on quantitative measures of animal welfare, capture efficiency, and selectivity, and consideration of trap practicality and user safety. We recommend all metrics be considered when making trap-selection decisions. Focus on only 1 metric can lead to unintended negative consequences such as poor animal welfare, ineffective response to threats to human property and safety, impractical trapping regulations, or wasted resources during wildlife research projects.

We intended BMPs to be implemented through a voluntary and educational approach and have simultaneously engaged in a multifaceted effort to facilitate this, including through extensive outreach and training to state wildlife agency staff, presentations at wildlife conferences, attendance at state and national trapping conventions to discuss and distribute BMPs, writing articles in popular trapping magazines, conducting national surveys on trap use in the United States, and developing a national trapper education program that incorporates key BMP principles and findings and is available to anyone. We recommend that wildlife management agencies and educational and research institutions, collaboratively with trap manufacturers and trapping organizations, vigorously continue this effort. The benefits include advancing our understanding of trap performance through research, developing trap innovations and trapper education programs that improve animal welfare and trap efficiency and selectivity, and increasing societal awareness of modern trap performance and the benefits of trapping.

Some regulatory agencies may consider use of our results to prohibit traps that do not meet BMP standards, but attempting to do so may result in numerous practical or regulatory challenges that must be carefully considered. Agencies must consider the reality that nearly all traps are BMP-compliant for at least 1 species, appropriate responses when a trap set for 1 species for which it meets BMP standards catches another legally harvestable species for which it does not, potential use of trap brand names in regulations, and how to determine when an untested trap is similar to one that has been tested. Conversely, regulatory agencies may use our findings to support decisions that allow the use of currently prohibited devices, such as has occurred in recent years with cable restraints in numerous states. Because state and tribal authorities are the primary management agencies that regulate capture or harvest of non-migratory wildlife, we assume the approach to BMP implementation will vary, but regardless of the approach, we strongly recommend that they encourage their use by all those directly or indirectly involved in the capture of furbearing mammals.

The live capture of furbearing animals remains an important component of wildlife research in the United States. For research projects that use live capture and require approval through an internal or external animal care and use committee, we encourage use of our findings to make science-based decisions during the development and implementation of research protocols, and where data are lacking, we recommend use of expert opinion. Restraining devices, including foothold traps, can be efficient and selective tools that produce minimal injury or risk of death when used by those with proper training and experience, whether for research, animal damage management, or avocational harvest.

The large scope of our research (i.e., nationwide testing of multiple trap types for development of trapping BMPs on 19 species) allowed us to detect consistent patterns and differences across species in the influence of trap attributes on several performance metrics. We recommend judicious use of generalizations about trap performance and that our species-specific results and online BMPs always be examined before selecting a trap. When seeking ways to improve trap performance, or in situations where performance data are lacking for a trap of potential interest, we offer the following general observations and recommendations based on our collective results and experience. First, selecting or modifying traps (or choosing where to set them) to reduce injury potential must closely consider the taxonomy, natural habitat and behavior, size, morphology, and physiology of the species of interest; response to restraint and the associated potential for different types of injury should inform proper trap selection, design, and modification. Second, when using foot-restraining traps for live capture, certain mechanical attributes are likely to lower injury risk under most circumstances, including 1) padded or wider-faced jaws (depending on species); 2) velocity and clamping forces that produce minimally acceptable trap efficiency, but no more than necessary to prevent the restrained foot from sliding between the jaws; 3) jaw spreads and pan tension controls that are most likely to result in a strike location near the center of the foot and across the pad; 4) a sufficient number of swivels in the chaining system to reduce potential for torsion-related injury; and 5) chain lengths and features (e.g., weight, shock absorbers) that give animals some freedom of movement, but not enough to increase the risk of serious lunging-related injury. Third, selection or design of traps should in most circumstances give equal consideration to the focal and other species that could be captured, particularly smaller species, which our data indicate are more vulnerable to injury even in smaller traps. Selectivity metrics cannot be interpreted in isolation and must be considered in the context of potential injury to any animal that may be captured, and selectivity-improving tools (e.g., pan tension devices or controls) and trap-setting methods (e.g., trap location, baits and lures) are a critical component of trap use and trapper education. Finally, where practical and cost-effective, cage traps are viable live-capture methods that typically produce few injuries, but designs with lower potential for tooth damage should be used or developed (e.g., solid-walled vs. wire mesh traps, appropriate wire mesh opening sizes, fewer internal mechanical components to bite).

Many currently used traps either meet BMP criteria or could easily be modified to do so; trap manufacturers and supply companies already provide components (e.g., jaw-lamination kits, add-on jaw pads) to modify restraining traps in ways consistent with specifications of BMP-approved traps. Manufacturers and inventors can use our results to improve designs that had poor performance to ensure they meet all BMP criteria. To further elucidate important relationships between trap mechanics and performance, future modeling or controlled research should examine the effects of specific quantitative measures that may more directly correlate with performance (e.g., velocity, clamping force, jaw thickness, jaw spread, pan tension, chain length, number of swivels).

The need for trapping BMPs was borne out of both national and international concerns related largely to animal welfare and selectivity. Our data and trapping BMPs are critical mechanisms by which to move those discussions forward in a more objective manner, and to help ensure that a variety of traps remain viable tools in wildlife research, wildlife conservation, wildlife damage management, and sustainable harvest of these species. As with other commodities and services, responding to societal or market-based concerns related to capture of wildlife is necessary for long-term viability.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

APPENDIX A. TRAP CODES AND MODELS

Table A1. Trap codes and models used to capture furbearing species in restraining traps in the United States during the best management practices for trapping program, 1997–2018. Brand names are used because manufacturers do not use standardized trap-size designations for individual trap models.

Trap code	Trap brand and model
B2P	Bridger[a] No. 2 coil-spring trap with padded jaws
BEL	Belisle[b] No. 6 power-activated foot-snare
BTH	Breathe Easy[c] cage-trap
Cage 105.5	Tomahawk[d] wire-mesh cage-trap (60.9-cm long, 17.8-cm wide, 17.8-cm high)
Cage 108	Tomahawk wire-mesh cage-trap (81.3-cm long, 25.4-cm wide, 32.4-cm high)
Cage 109.5	Tomahawk wire-mesh cage-trap (106.7-cm long, 38.1-cm wide, 50.8-cm high)
Cage 207	Tomahawk wire-mesh cage-trap (81.3-cm long, 25.4-cm wide, 30.5-cm high)
HAN	Hancock[e] cage-trap
CC	Coon Cuffs[f] foot encapsulating trap
CCC	High Country[g] Circle C Coyote Cuff No. 3 coil-spring with offset wide face jaws
CD	Coon Dagger[h] foot-encapsulating trap
DPP	Duke[i] DP foot-encapsulating trap
DUF	Duffer[j] foot-encapsulating trap
EGG	Egg[k] foot-encapsulating trap
HE	Black Hole[l] trigger assembly added to the 15C
JAKE	J. C. Conner[m] Jake coil-spring trap with padded jaws
KB5.5	KB[n] Compound 5.5 foothold trap with outside-laminated offset jaws
LPC4G	Livestock Protection Company[o] No. 4 double longspring trap with offset jaws, anchored with grapple
LPC4K	Livestock Protection Company No. 4 double longspring trap with offset jaws, anchored with stake
MB450	Minnesota Brand[p] MB450-FOX foothold trap
MB550-RC	Minnesota Brand 550-RC foothold trap
MB650	Minnesota Brand MB650 foothold trap with offset cast jaws
MB750C	Minnesota Brand MB750 foothold trap with standard jaws
MB750G	Minnesota Brand MB750 foothold trap with outside-laminated offset jaws, anchored with grapple
MB750K	Minnesota Brand MB750 foothold trap with outside-laminated offset jaws, anchored with stake
MJ600	Sterling[q] MJ600 foothold trap
MS1.5	Montana[r] Special 1.5 coil-spring trap
RZ	Lil' Grizz Get'rz[s] foot-encapsulating trap
T3	Bridger T3 foot-encapsulating trap
ZT	Z-Trap[t] foot-encapsulating trap
1C	Oneida[u] Victor No. 1 coil-spring foothold trap with standard jaws
1L	Oneida Victor No. 1 coil-spring foothold trap with outside-laminated jaws
1P	Oneida Victor Soft Catch No. 1 coil-spring foothold trap with padded jaws
1DJ	Sleepy Creek[v] No. 1 coil-spring foothold trap with double jaws
1VG	Oneida Victor Stop-Loss No. 1 longspring foothold trap with spring-activated immobilization guard
11P	Sleepy Creek No. 11 double longspring foothold trap with padded jaws
11S	Sleepy Creek No. 11 double longspring foothold trap with standard jaws
11CH	Sleepy Creek No. 11 double longspring foothold trap with Humane Hold™ jaw pads
11DJ	Sleepy Creek No. 11 double longspring foothold trap with double jaws
11DJG	Sleepy Creek No. 11 double longspring foothold trap with double jaws, anchored with grapple
11DJK	Sleepy Creek No. 11 double longspring foothold trap with double jaws, anchored with stake
11DJO	Sleepy Creek No. 11 double longspring foothold trap with offset double jaws
15C	Oneida Victor No. 1.5 coil-spring foothold trap with standard jaws
15L	Oneida Victor No. 1.5 coil-spring foothold trap with outside-laminated jaws
15P	Oneida Victor Soft Catch No. 1.5 coil-spring foothold trap with padded jaws
15C6	Oneida Victor No. 1.5 coil-spring foothold trap with standard jaws, 15.2-cm-long chain
15C30	Oneida Victor No. 1.5 coil-spring foothold trap with standard jaws, 76.2-cm-long chain
15CH	Oneida Victor No. 1.5 coil-spring foothold trap with Humane Hold™ jaw pads
15CQ	Oneida Victor No. 1.5 coil-spring foothold trap with standard jaws, chain attachment on trap corner, stronger springs
15DJ	Oneida Victor No. 1.5 coil-spring foothold trap with double jaws
15DJL	Oneida Victor No. 1.5 coil-spring foothold trap with laminated double jaws
15FO	Sleepy Creek No. 1.5 coil-spring foothold trap with offset wide jaws
15PM	Oneida Victor Soft Catch No. 1.5 coil-spring foothold trap with padded jaws, 4 coil-springs
15PT	Oneida Victor Soft Catch No. 1.5 coil-spring foothold trap with stronger coil-springs

(*Continued*)

Trap code	Trap brand and model
15CQW	Oneida Victor No. 1.5 coil-spring foothold trap with standard jaws, chain attachment on trap corner, weaker coil-springs
15DJG	Oneida Victor No. 1.5 coil-spring foothold trap with symmetrical double jaws, anchored with grapple
15DJK	Oneida Victor No. 1.5 coil-spring foothold trap with symmetrical double jaws, anchored with stake
15DJL	Sleepy Creek No. 1.5 coil-spring foothold trap with laminated double jaws
15DJM	Oneida Victor No. 1.5 coil-spring foothold trap with double jaws, 4 coil-springs
15DOL	Duke 1.5 coil-spring with inside lamination
15PDJ	Oneida Victor No. 1.5 coil-spring foothold trap with padded double jaws
15VDJ	Oneida Victor No. 1.5 coil-spring foothold trap with asymmetrical double jaws
15DJFO	Sleepy Creek Manufacturing No. 1.5 coil-spring foothold trap with flat-faced offset double jaws
15DJFO4	Sleepy Creek Manufacturing No. 1.5 coil-spring foothold trap with flat-faced offset double jaws, 4 coil-springs
134FO	Sleepy Creek Manufacturing No. 1 3/4 coil-spring foothold trap with offset wide jaws
165DOL	Bridger No. 1.65 coil-spring foothold trap with outside-laminated jaws
165OL	Bridger No. 1.65 coil-spring foothold trap with outside-laminated offset jaws
175C	Oneida Victor No. 1.75 coil-spring foothold trap with standard jaws
175OL	Oneida Victor No. 1.75 coil-spring foothold trap with outside-laminated offset jaws
175FOJ	Oneida Victor No. 1.75 coil-spring foothold trap with offset, wide-face jaws
175P	Oneida Victor Soft Catch No. 1.75 coil-spring foothold trap with padded jaws
2C	Oneida Victor No. 2 coil-spring foothold trap with standard jaws
2P	Butera[w] Cushion-Catch No. 2 coil-spring foothold trap with padded jaws
2S	Oneida Victor No. 2 double longspring foothold trap with standard jaws
2FOJ	Oneida Victor No. 2 coil-spring foothold trap with offset wide jaws
2OLM	Bridger No. 2 coil-spring foothold trap with inside-laminated offset jaws
22CC	High Country Control Coyote Cuffs No. 22 coil-spring foothold trap with offset wide cast jaws
3C	Oneida Victor No. 3 coil-spring foothold trap with standard jaws
3L	Bridger No. 3 coil-spring foothold trap with outside-laminated jaws
3O	Bridger No. 3 coil-spring foothold trap with offset jaws
3S	Sleepy Creek Manufacturing No. 3 double longspring foothold trap with standard jaws
3OL	Bridger No. 3 coil-spring foothold trap with outside-laminated offset jaws
3PM	Oneida Victor Soft Catch No. 3 coil-spring foothold trap with padded jaws and 4 coil-springs
33CC	Bridger No. 3 coil-spring with Coyote Cuffs No. 33 offset wide cast jaws
3MSM	Montana Special No. 3 coil-spring modified foothold trap with outside-laminated offset jaws

[a] Bridger Trap Company, Pennock, MN, USA
[b] Belisle Enterprises, Blainville, QC, Canada
[c] Breathe Easy Trap Inc., Truro, NS, Canada
[d] Tomahawk Live Trap, Hazelhurst, WI, USA
[e] Hancock Trap Company, Custer, SD, USA
[f] Blue Valley Trap Supply, Pickrell, NE, USA
[g] High Country Control, Model, CO, USA
[h] Sudden Valley Supply, Warrenton, MO, USA
[i] Duke Company, West Point, MS, USA
[j] Duffer's Trap Company, Bern, KS, USA
[k] The Egg Trap Company, Butte, ND, USA
[l] Bill Rudy, Aurora, NE, USA
[m] J. C. Conner, LTD., Newcomerstown, OH, USA
[n] Kurt Beauregard, Fort Plain, NY, USA
[o] The Livestock Protection Company, Alpine, TX, USA
[p] Minnesota Trapline Products, Pennock, MN, USA
[q] Glen Sterling (deceased), Hulett, WY, USA
[r] Montana Traps, Lusk, WY, USA
[s] Sterling Fur Company, Sterling, OH, USA
[t] Z Traps, Lake View, IA, USA
[u] Oneida Victor Inc., Ltd., Cleveland, OH, USA
[v] Sleepy Creek Manufacturing, Berkeley Springs, WV, USA
[w] Butera Manufacturing Ind., Wickliffe, OH, USA