1   **Determinants of invasive species policy: print media and agriculture determine United**

2   **States invasive wild pig policy**

3

4   Ryan S. Miller[1,3], Susan M. Opp [2], Colleen T. Webb [3]

5

Author Affiliation:

[1] USDA, APHIS, Veterinary Services, Center for Epidemiology and Animal Health

[2] Department of Political Science, Colorado State University

[3] Department of Biology, Colorado State University

Correspondence:

Ryan S. Miller

2150 Centre Avenue, Bldg B

Fort Collins, Colorado, 80526 USA

Email: Ryan.Miller@rsmiller.net; Ryan.S.Miller@aphis.usda.gov

Telephone: 1.970.494.7327 office 1.970.215.2055 cell

Fax: 1.970.494.7319

6

7

8 Abstract

9 Conflicts between wildlife, invasive species, and agricultural producers are increasing. Although

10 direct management actions taken to mitigate these conflicts remain controversial, most

11 stakeholders agree that better policies are needed to balance socio-economic considerations with

12 invasive species management, wildlife conservation, and agriculture. However the interaction

13 between societal and biological drivers that influence human-invasive species-wildlife conflict

14 mitigation policy is poorly understood. We identify factors influencing policy leading to the

15 establishment of a new federal program to control invasive wild pigs in the United States. We fit

16 generalized linear models relating frequency of congressional policy activity, such as

17 congressional hearings and reports, to frequency of print newspaper media and percent of the

18 U.S. agricultural industry co-occurring with invasive wild pigs for 29 years preceding the

19 establishment of the federal program in 2013. Our models explained 89% of the deviance in

20 congressional policy activity indicating a strong linkage between congressional invasive wild pig

21 policy activity and predictors representing the number of negative of newspaper articles,

22 geographic distribution of print media, and percent of agricultural producers co-occurring with

23 invasive wild pigs. These effects translated to 3.7% increase in the number of congressional

24 policy actions for every additional five states with negative news media. Invasive wild pig

25 congressional policy activity increased 6.7% for every additional 10 negative newspaper articles.

26 Increases in co-occurrence of agriculture and invasive wild pigs had the largest effect, for every

27 1% increase in co-occurrence there was a 41% increase in congressional policy activity. Invasive

28 wild pig congressional policy activity that explicitly addressed livestock increased at nearly

29 twice the rate of policy activity addressing crop agriculture. These results suggest that agriculture

30 and media coverage may act as determinants for invasive species policy. Our approach may

31   provide early insight into emerging policy areas enabling proactive policy development by

32   agencies or early engagement by scientists to find solutions before the policy area becomes grid

33   locked. Our results can also support policy and program evaluation providing a means of

34   determining if the implemented policies match the original policy determinants ensuring best

35   alignment with public, environmental, and stakeholder interests.

36

37

38

39   **Key Words:**

40   Agriculture; conflict, policy, wildlife, human, feral swine, invasive, wild pig, United States,

41   livestock, model, policy making

42   **Introduction**

43   Conflicts between wildlife, invasive species, and agricultural producers are increasingly

44   challenging management agencies (Krebs et al. 1998, Miller et al. 2013, Miller and Sweeney

45   2013). Policy to address human-wildlife-invasive species conflicts is often controversial

46   (Messmer 2009, Crowley et al. 2017). Although policies to manage interactions among invasive

47   species, wildlife, and agriculture has been identified as critically important (Jones et al. 2013,

48   Paini et al. 2016) and there have been focal studies (McBeth and Shanahan 2004, Kokotovich

49   and Andow 2017), little research has been conducted to identify societal factors that stimulate

50   federal policy development to address these conflicts. This gap is particularly evident for

51   invasive species conflicts which can have complex societal and management drivers (Estévez et

52   al. 2015, Crowley et al. 2017). The drivers that often influence policy development to address

53   social problems include problem severity, interest group involvement, media coverage, and

54   public perceptions (Gilliam Jr and Iyengar 2000, Soroka 2003, Walgrave et al. 2008,

55   Baumgartner and Jones 2010).

56   Agriculture and wildlife policy development is often exacerbated by invasive or exotic

57   animals (Pimental 2007). North America and in particular the United States (U.S.) has the

58   greatest number of non-native invasive species globally, causing an estimated $46 billion in

59   damage annually (Pimental 2007, Turbelin et al. 2017). The invasive wild pig (IWP) *Sus scrofa*,

60   often referred to as feral hog, feral pig, feral swine or wild boar, are the most abundant free-

61   ranging, exotic ungulate in the U.S. and are the descendants of Eurasian Russian boar (*Sus

62   scrofa linnaeus*), feral domestic swine (*Sus scrofa domestica*), and hybrids between the two

63   (Mayer and Brisbin 1991, Keiter et al. 2016). Since the 1960s IWPs have expanded their range to

64   at least 38 states and 3 provinces in Canada impacting ecosystems, wildlife, and agricultural

65   (Bevins et al. 2014, Brook and Beest 2014, Michel et al. 2017, Miller et al. 2017). Environmental

66   and agricultural damage caused by IWPs is at least USD$1.5 billion annually (Pimental 2007,

67   Bevins et al. 2014, Anderson et al. 2016). The rooting behavior and omnivorous diet of IWPs can

68   have ecosystem-level effects on native plant and wildlife communities and has complicated

69   threatened and endangered species conservation with at least 87% of imperiled species

70   potentially impacted in the United States (Barrios-Garcia and Ballari 2012, McClure et al. 2018).

71   There is a diversity of public attitudes toward IWPs depending on if the animals are seen

72   as pests, disease hazard, commodity, source of income, or recreational resource (Tisdell 1982,

73   Izac and O'Brien 1991, Caplenor et al. 2017). Economic impacts and perceived problem severity

74   often differ regionally. Despite economic costs IWPs are also valued as an economically

75   important hunting resource with 35 states currently allowing public hunting and in 11 states

76   IWPs are under the jurisdiction of the state game and fish agency (Centner and Shuman 2015,

77   Group' 2016, Caplenor et al. 2017). Izac and O'Brien (1991) found that these perceptions

78   changed with location, overtime and how an individual may be affected. This diversity of public

79   opinion influences public discourse concerning how IPWs should be managed subsequently

80   affecting institutional (e.g. governmental agencies) problem identification and implementation of

81   policies to control or mitigate the damage caused by IWPs.

82   Conflict over public policies can be decomposed into the scope of participation by

83   affected parties and how the problem and its solutions are perceived (Schattschneider 1960).

84   These two aspects of policy conflict are useful in understanding the relative contribution of

85   interest groups and public perception of the problem to policy development. Extensive work in

86   the policy analysis literature indicates that identifying the visible, and presumably most affected

87   (often economically affected), participants in a policy issue is central to understanding why some

88   policy problems receive attention by governmental institutions resulting in policy development

89   (Kingdon and Thurber 1984, Baumgartner and Jones 1991, Jones and Baumgartner 2004,

90   Baumgartner et al. 2009, Baumgartner and Jones 2010). This is often tied to increasing problem

91   severity that often results in increased lobbying by interest groups and can be a significant

92   stimulus for the adoption of policy innovations (Sapat 2004). The dominant conceptualization of

93   a policy problem and the solutions, often referred to as the 'policy image', is also important in

94   understanding policy development (Barrilleaux et al. 2017). Media coverage of public issues –

95   both quantity and tone (i.e. negative or positive) - has been widely recognized as an important

96   driver in shaping national public perception and perceived importance of policies issues thus

97   influencing government institution policy agendas (Gilliam Jr and Iyengar 2000, Walgrave et al.

98   2008, Baumgartner and Jones 2010). Media coverage is generally thought to effect government

99   policy agendas by increasing the relative salience (i.e. importance) of a particular pubic issue and

100   increasing policy image coalescence often early in the policy process (Elder and Cobb 1983,

101   Weart 1988, Soroka 2003, Baumgartner and Jones 2010). Salience and coalescence of a policy

102   image is often translated into pressure on government officials to prioritize development of

103   policy solutions.

104   There is mixed evidence for how these factors - media coverage, public perception,

105   problem severity, and interest groups - may act together to influence policy generation

106   (McCombs and Shaw 1972, Funkhouser and Shaw 1990, Entman 1993, Koch-Baumgarten and

107   Voltmer 2010) and there is generally poor understanding of how they may influence policy

108   addressing conflicts among invasive species, wildlife, and agricultural (McBeth and Shanahan

109   2004, Lodge and Matus 2014). Our objectives in this study were to characterize the relative

110   contribution of these factors to the development of national invasive species policy. Specifically

111   we wanted to understand 1) the significance of public policy image on congressional policy

112   activity (e.g. congressional hearings and reports) to address invasive species conflict; 2)

113   determine the contribution of problem severity and the resulting pressures on government

114   institutions from interest groups to develop policy solutions; and 3) to identify predictors of

115   policy activity for informing invasive species management and policy; specifically program

116   assessments and new program development. To investigate these relationships we use 29 years

117   of federal congressional policy activity leading to the establishment of the Animal Plant Health

118   Inspection Service (APHIS) National Feral Swine Damage Management Program in 2013

119   (federal government fiscal year 2014) (USDA 2013). The broader goal of this analysis is to

120   provide a mechanistic understanding of factors contributing to invasive species policy enabling

121   improved development of policies to manage conflicts with invasive species.

122   **Methods**

123   *Congressional policy activity data*

124   A systematic search of the Federal Digital System (FDsys) maintained by the United

125   States Government Printing Office (GPO 2014) was used to generate data describing

126   congressional policy activity related to IWPs. We use the term 'policy activity' in its broadest

127   definition referring not only to operational policies of government (e.g. code of federal

128   regulations) but also including all official discourse related to the development of policy (e.g.

129   committee hearings and congressional reports). The FDsys is an official repository of all official

130   publications from all branches of the United States Federal Government and currently contains

131   over 7.4 million electronic documents from 1969 to present. Our search included congressional

132   hearings, congressional record, congressional reports, bills, and changes to the code of federal

133   regulations from 1985 until 2013 when the APHIS National Feral Swine Damage Management

134   Program was established. FDsys documents included in our study contained any of the following

135   search terms: 'feral swine', 'feral hog', or 'feral pig', 'wild swine', 'wild hog', or 'wild pig'.

136   Each document was considered an independent policy action, and the number of

137   documents by year was tallied to generate count data by document type and the primary

138   agricultural commodity (livestock or crop) the document addressed. Our method may have

139   included documents which were not specifically addressing IWP related policy. Because it was

140   prohibitive to manually assess 476,000 pages of policy documents to evaluate inclusion error, we

141   randomly sampled 5% of the documents to determine if they addressed IWP policy allowing

142   inclusion error greater than 4.5% with 95% certainty to be detected (Valliant et al. 2013). Based

143   on the results of this assessment we assumed that if the document contained a reference to IWPs

144   the issue was either on the policy agenda or influencing the agenda in some way (Baumgartner

145   and Jones 2010).

146   The policy process is an often nonlinear multi-stage cycle that can be characterized into

147   at least six primary stages that include, 1) issue emergence and problem formation, 2) agenda

148   setting, 3) formulation 4) policy adoption, 5) implementation, 6) evaluation (Brewer and DeLeon

149   1983, Anderson 1984). These six stages often overlap, often have additional hierarchy of stages,

150   and are not always required for policy to be in-acted (Sabatier and Weible 2014). To support our

151   statistical analyses the policy documents were used to identify the primary policy stages that

152   IWP policy likely experienced. We used the policy stage heuristic to determine the policy stages

153   that IWP policy likely experienced (Brewer and DeLeon 1983, Anderson 1984) (see Appendix

154   S1). These stages were then used in post-hoc analysis of the contribution of our policy model

155   predictors to overall policy activity (see Policy models methods).

156   *Print media data*

157   Data on media reporting of IWP related topics was generated using a search of four major

158   news consolidators – Newsbank, LexisNexis, EBSCO Information Services, and ProQuest

159   (EBSCO 2016, LexisNexis 2016, NewsBank 2016, ProQuest 2016). We used similar search

160   criteria to that used for the policy activity data. Our review was restricted to print newspaper

161   articles (here after referred to as articles) published from 1985 to 2013 in the United States

162   contained in these databases. In order for an article to be included it must have contained the

163   terms 'feral swine', 'feral hog', or 'feral pig', 'wild swine', 'wild hog', or 'wild pig' in the title

164   or lead into the article. Articles published by the same newspaper and author on the same date

165   were considered duplicates and removed. The data were tallied by year to generate three annual

166   predictors, the number of articles, the number of different newspapers, and the number of states

167   with at least one article. A state was considered to have an article if the newspaper was located

168   in the state. For national newspapers such as the New York Times, the head office was used to

169   determine the state (e.g. the New York Times would be located in New York).

170   To generate a measure of article tone, each article headline was classified as positive or

171   negative (see detailed methods in Appendix S2). Our assumption was that the article headline

172   summarized the content and sentiment of the article representing the overall tone of the article

173   and has previously been used as an index of tone (Dodds et al. 2011, Dodds et al. 2015). We

174   classified articles as having positive or negative tone using an index previously described by

175   Rinker (2013) and Liu (2015) using the polarity function in the Qualitative Data and Quantitative

176   Analysis package (Rinker 2013) within the R computing environment (R Core Team 2016).

177   Briefly, the polarity algorithm uses a word sentiment (positive or negative) dictionary to identify

178   and assign a score to polarized words in the article headline (Hu and Liu 2004). The words

179   adjacent to the polarized word, often referred to as the context cluster, are used to weight the

180   score for the polarized word. The weighted scores for each polarized word within the article

181   headline are summed and divided by the square root of the word count for the headline yielding

182   an unbounded score for article tone in which zero is perfectly neutral, positive values indicate

183   positive tone and negative values indicate negative tone.

184   We were interested in the annual influence of article tone and newspaper tone on policy

185   activity. To this end the polarity scores for each article were used to calculate the mean article

186   tone (article tone) in each year across all articles. To calculate the annual mean newspaper tone

187   we first calculated the mean article tone by newspaper in each year. This represented the mean

188   article tone for each newspaper in each year (i.e. tone of articles published by each newspaper).

189   We then calculated the mean newspaper tone across all newspapers in each year providing a

190   measure of mean annual newspaper tone (newspaper tone). A detailed description of the

191   methods used to generate article and newspaper tone using the polarity index are described in

192   Appendix S2.

193   *Increasing problem severity and interest group pressures*

194   The most affected participants, often economically, in a policy area often determine

195   policy outcomes (Kingdon and Thurber 1984, Baumgartner and Jones 1991, Jones and

196   Baumgartner 2004, Baumgartner et al. 2009, Baumgartner and Jones 2010). Increasing problem

197   severity and economic losses often increase lobbying by interest groups and is considered a

198   primary mechanism of interest group engagement (Sapat 2004) In the case of IWPs there are

199   several potentially affected interest groups including wildlife conservation, sportsmen, and

200   agriculture. Agriculture likely has the largest economic impacts resulting from IWPs

201   (~USD$1.5billion) although the economic impacts to sportsmen and wildlife are not as easily

202   estimated or available (Pimental 2007). We limited our investigation to agricultural interest

203   groups which are likely the most economically affected group.

204   To generate a measure of potential interest group pressures on governmental institutions

205   (here after institutional pressure) we developed a proxy variable describing the co-occurrence of

206   agricultural producers and IWPs. Data describing the nationwide distribution (presence/absence)

207   of wild swine at the county level was compiled from the Southeastern Cooperative Wildlife

208   Disease Study (SCWDS) (Corn and Jordan , SCWDS 2013) and two publications Waithman et

209   al. (1999) and Hanson and Karstad (1959). These data represent the known nationwide county

210   level distribution of IWPs for 39 states and 1,521 counties over the past 50 years and have been

211   used to forecast the spread of IWPs (Snow et al. 2017), estimate the probability of occurrence

212   (McClure et al. 2015), and determine agricultural producers at risk for damage from IWPs

213   (Miller et al. 2017). For each year and county with IWP presence the number of agricultural

214   producers was determined using the National Agricultural Statistics Service (NASS) data

215   (USDA 2014). Because data describing the distribution of IWPs were not available for all years

216   and represent a sample of the known distribution of IWPs over time, models were fit to these

217   data to estimate the total number of agricultural producers in counties where IWPs occur for each

218   year of policy data (McClure et al. 2018). To improve estimation for earlier years where IWP

219   distribution data is sparse we used all IWP – producer data to fit the models. We determined

220   relative support in the data using four candidate models - linear, exponential, power, and logistic

221   - to describe the phenomenological change in national co-occurrence of IWPs and agriculture.

222   Akaike information criterion with a correction for small sample size (AICc) was used to

223   determine the best approximating model. This model was used to predict the mean national

224 proportion of agricultural producers co-occurring with IWPs for each year from 1985 to 2013

225 and was used as a predictor in the policy models.

226 *Policy models*

227   We evaluated support for competing models portraying the relationship between the

228 annual count of policy actions (response variable) and six variables of interest measuring

229 annually the 1) number of articles, 2) number of newspapers with articles, 3) number of states

230 with articles, 4) tone for articles, 5) tone for newspapers, 6) and the proportion agricultural

231 producers in regions with IWPs, here on referred to as agriculture. Specifically, these

232 independent variables represent three hypotheses about specific mechanisms that resulted in

233 congressional policy activity that eventually resulted in the establishment of a national program

234 to address the problem.

235 *Problem Salience*: An increase in the number of articles, newspapers with articles, and the

236 number of states with newspaper articles would increase the salience of the policy image

237 increasing congressional policy actions.

238 *Problem Coalescence*: An increase in negative newspaper article tone for IWPs represents

239 coalescence of the policy image increasing congressional policy activity.

240 *Institutional Pressures*: Increasing the number of agricultural producers in IWP regions is related

241 to increasing problem severity and results in increased pressures on Federal government

242 institutions by interest groups (i.e. lobbying) to find a policy solution thus increasing

243 congressional policy activity.

244   We used multi-model inference within an information-theoretic framework to estimate

245   model parameters describing the probability of congressional policy actions related to IWP co-

246   occurrence with agriculture and media tone (Burnham and Anderson 2002, Burnham et al. 2011).

247   All models used a Poisson error structure and were fit using a generalized linear model (GLM)

248   with a log link function having the form:

249                                $$y_i = Poisson(\theta_i)$$

250   Where y_i represented congressional policy actions in year i and θ_i is the Poisson rate parameter

251   representing the mean number of congressional policy actions in a year. The mean number of

252   congressional policy actions, θ_i, was a function of covariates on the logarithmic scale

253   represented as:

254                                $$\theta_i = exp(\alpha + \beta x_i^T)$$

255   Where α was the intercept describing the estimated background number of congressional policy

256   actions common across years, β is a vector of regression coefficients corresponding to x_i^T, the

257   transpose of the of the $m \times 1$ vector of covariates associated with the ith year in the

258   congressional policy data.

259   Among year correlation in the number of congressional policy actions was investigated

260   using generalized linear autoregressive moving average (GLARMA) models (see Appendix S3),

261   however models that accounted for serial dependence in the response variable were not

262   significantly different than a GLM indicating between year dependence in policy actions was not

263   important thus we did not include serial dependence in our models.

264   Akaike information criterion with a correction for small sample size (AICc) was used to

265   assess the relative information content of the models. We fit all subsets of the global model and

266   computed model-averaged regression coefficients, unconditional standard errors (SE),

267   cumulative AICc weights of evidence as a measure of variable importance and 95% confidence

268   intervals (Burnham and Anderson 2002, 2004, Burnham et al. 2011). Because the policy data are

269   over-dispersed we used a shrinkage estimation approach to produce unconditional model

270   averaged parameter estimates, in which covariates that did not appear in a particular model

271   subset were assigned coefficients of zero to avoid biasing coefficient estimates away from zero

272   (Burnham and Anderson 2002). Our interpretation of the explanatory power of the regression

273   coefficients in our model was guided by: 1) the weights of evidence, ranging from 0 to 1.0,

274   where higher weights indicated greater relative importance; 2) the 95% confidence interval for

275   each regression coefficient that did not overlap zero; and 3) effect sizes indicated by each

276   regression coefficient.

277   The final inferential model was used to estimate the mean annual contribution of each

278   predictor (i.e. influence on the amount of policy activity in each year) to policy activity across

279   the 29 years investigated. We also estimate the relative contribution of livestock and crop

280   agriculture to annual federal policy activity for IWPs. Differences in the contribution among

281   predictors to policy activity was determined using Tukey's honest significant difference test

282   (Kleinbaum et al. 2013) for each of the policy stages identified using the policy documents.

283   Maximum likelihood estimates, confidence intervals on model parameters, significance statistics,

284   and AICc values were obtained using MuMIn Multi-Model Inference package (Barton and

285   Barton 2015) available in R (R Core Team 2016).

286   *Model assessment and validation*

287   We assessed model fit using k-fold cross-validation which contrasts the number of policy

288   actions predicted by the model and the observed frequency of policy actions (Kohavi 1995) and

289   calculated adjusted D^2 which is a quality-of-fit statistic (Guisan and Zimmermann 2000,

290   Weisberg 2005). To implement k-fold cross validation we randomly divided the policy action

291   data among four cross-validation folds using Huberty's rule (Huberty 1994). We used all

292   possible sets of three folds to fit the predictive model. Employing multi-model averaging, we

293   then used the model to predict the fourth withheld fold. Results of 100 iterations of this process,

294   each with a new random allocation of data across the folds, were averaged to avoid dependency

295   on a single random allocation of data. We then calculated a Pearson correlation between

296   predicted values and the observed number of policy actions. The Pearson correlation was used to

297   assess the performance of our final model. Because validation results can be sensitive to binning

298   method (Boyce et al. 2002), we applied and compared the results using a quantile binning

299   method for 4, 10 and 20 bins. We also calculated adjusted D^2 which is a measure of the amount

300   of deviance the model accounts for adjusted by the number of observations and the number of

301   model parameters (Guisan and Zimmermann 2000, Weisberg 2005). Adjusted D^2 allows direct

302   comparison among different models. Adjusted D^2 was calculated using the modEvA package

303   (Barbosa et al. 2016) and cross-validation was implemented using custom code in the R

304   statistical software (R Core Team 2016).

305   **Results**

306   *Congressional policy activity*

307   Our search of FDsy for policy documents identified 421 documents related to IWPs

308   (Figure 1). The policy documents represented three primary policy stages of increasing policy

309   activity described by (Anderson 1984) – issue emergence and problem formation, agenda setting,

310   policy formulation and implementation (see Appendix S1). The period from 1985 to 1993

311   showed no observed policy activity followed by a brief period of regulatory activity from 1994

312   to 1998 (e.g. changes to the federal register and the code of federal regulations) indicating that

313   IWP policy was not yet formally present on institutional agendas and the issue was still emerging

314   (Anderson 1984, Baumgartner and Jones 1991). From 1999 to 2006 policy activity on IWPs

315   began in the form of congressional hearings indicating that the topic of IWPs had reached the

316   institutional agendas of policy makers (Baumgartner and Jones 1991, 2010). The last stage was

317   dominated by policy formulation and implementation from 2007 to 2013 which accounted for

318   64% of the total policy activity and comprised both regulatory and distributive policies (i.e.

319   allocation of fiscal resources to address specific issues related to IWPs) and culminated in the

320   establishment of a national program to address IWP damage.

321   *Invasive wild pig print media*

322   We identified 980 unique articles from 452 newspapers related to IWPs between 1985

323   and 2013 (Figure S2.1). The number of articles, number of newspapers and number of states with

324   newspaper articles were relatively constant prior to 1998 with a rapid increase in articles,

325   newspapers, and states after 1999. This period from 1999 to 2013 accounted for 96% of articles

326   and 85% of newspapers. The number of states with wild swine related newspaper articles

327   continued to increase throughout the study period with 47 states having at least one article.

328   *Co-occurrence of invasive wild pigs and agriculture*

329   The co-occurrence of IWPs and agriculture expanded at an increasing rate from 1959

330   until 2013 and was best approximated by a logistic model (Table 1). For our study period the

331   national proportion of agricultural producers in regions with IWPs increased from 0.17 in 1985

332   to 0.41 in 2013 (Figure 2 panel B) and is similar to changes in co-occurrence of domestic animal

333   production and IWPs found in at least one other study (Miller et al. 2017). This represented an

334   annual rate of increase of 1.01 (stdev <0.01) in the co-occurrence of agricultural producers and

335   IWPs during this period. Based on the strong predictive capacity of this distribution (adjusted R^2

336   = 0.99) it was used as a predictor in the policy models to represent the annual number of

337   agricultural producers potentially impacted by IWPs and provided a surrogate variable for

338   changes in institutional pressure potentially resulting from interest group activity (i.e. lobbying).

339   *Policy models*

340   Based on the final inferential model, policy activity was most strongly associated with the

341   number of states with newspaper articles, media source tone, newspaper article tone, and the

342   number of agricultural producers co-occurring with IWPs (Table 2 and Table 3). Covariates

343   representing each of these four factors had high AICc weights of evidence and 95% confidence

344   intervals that did not include zero indicating high predictive importance. The final model

345   accounted for most of deviance with an adjusted D^2 of 0.89. Cross-validation indicated that the

346   final model had strong predictive capacity. The quantile binning method produced similar

347   Pearson correlations of 0.969 (4 bins), 0.915 (10 bins) and 0.957 (20 bins) between predicted

348   policy actions and the observed policy actions.

349   Parameter estimates, odds ratios, unconditional confidence intervals, and AICc weights

350   for the predictor variables considered are presented in Table 3. The number of states with IWP

351   related newspaper articles was a positive predictor of IWP policy activity (odds ratio = 2.08). For

352   every additional 5 states with newspaper headlines related to IWPs there was a 3.65% increase in

353   the number of policy actions. Increasing negative tone of the number of newspaper articles (odds

354   ratio = 1.95) and the number of media sources (odds ratio = 1.14) increased the number of IWP

355   policy actions. That is for every 10 negative newspaper articles and 10 negative media sources

356   IWP policy activity increased by 6.7% and 1.3%. The number of agricultural producers in

357   regions with IWPs was the most significant predictor of policy actions (odds ratio = 4.09); that is

358   for every 1% increase in the proportion of agriculture in regions with IWPs policy activity

359   increases by 41%. The amount of agriculture in wild swine regions was also a significant

360   predictor of livestock (odds ratio = 4.08) and crop (odds ratio = 3.43) specific policy activity for

361   IWPs. Figure 3 illustrates the functional relationship between increasing co-occurrence of

362   agriculture and IWPs and the resulting change in IWP policy activity.

363   The predicted contribution of the four most important predictors to policy activity

364   changed across the 29 years evaluated and differed for the three policy stages identified (Figure 4

365   and Figure S1.1). During the problem formation stage from 1985-1998 all media predictors

366   contributed greater to policy activity than agriculture (p-values < 0.001) and source tone

367   contributed more than either article tone or states with media (p-values < 0.001) (see Appendix

368   S4). There was no difference in the mean contribution among the predictors during the policy

369   agenda setting stage from 1999 to 2006 (p-values > 0.05). During the policy formation and

370   implementation stage from 2007 to 2013 agriculture contributed more (p-values < 0.05) to policy

371   activity compared to media predictors and there was no difference in the contribution among

372   media predictors (p-values > 0.05). Livestock specific policy activity was greater (p-values <

373   0.05) than crop policy activity across all years. The mean annual predicted contribution of

374   agriculture to policy activity varied the most, with a 54.9% change from 5.5% of policy activity

375   in 1985 to 60.7% of policy activity in 2013. Both media source and newspaper article tone had

376   declining mean annual contribution to policy activity, declining 37.5% and 17.2%. Combined

377 media source and article tone contributed on average 30.5% of policy activity in 2013 compared

378 to a combined 71.7% in 1985. The number of states with newspaper articles on average

379 contributed a consistent amount annually (22.8%) to policy activity across all years.

380 **Discussion**

381 Our models found a linkage between policy activity and four predictors representing

382 number of states with media, media tone and agriculture. These predictors have been described

383 in previous studies as representing policy image salience, policy image coalescence, and

384 institutional pressures (Elder and Cobb 1983, Kingdon and Thurber 1984, Weart 1988, Gilliam Jr

385 and Iyengar 2000, Schnell 2001, Soroka 2003, Sapat 2004, Walgrave et al. 2008, Baumgartner

386 and Jones 2010). We found the predicted contribution of these predictors to policy activity

387 changed across the 29 years analyzed and differed for the three policy stages indicating the

388 development of federal IWP policy went through a continuum of policy development.

389 Understanding how these predictors, that serve as proxy measures of mechanisms influencing

390 policy processes, contribute to policy development can provide a better understanding of

391 important latent processes that give rise to national policies. This in turn can support the

392 development of programs and policies that best address the social issues underlying these

393 problems.

394 The emergence of invasive IWPs as a policy issue was characterized by decades of

395 general inattention and no observed policy activity (Figure 1; Appendix S1). Media predictors

396 contributed most to policy activity during the first stage of policy activity and may have acted to

397 increase policy image salience and coalescence (Figure S1.1). Our results suggest that for IWP

398 policy, increasingly negative news media may have acted as a mechanism for influencing initial

399   policy activity. Previous studies have proposed that increasing news media, specifically negative

400   news media, indicates increasing public policy image coalescence and policy issue salience

401   (Jones and Baumgartner 2004, Baumgartner and Jones 2010). Salience of social issues in public

402   discourse may determine whether or not issues expands on the government agenda (Koch-

403   Baumgarten and Voltmer 2010). For example issue salience can determine voter turnout and

404   choice preferences (Becker 1977). Our analysis suggests that print news media may have

405   provided a method for establishing issue salience and coalescence, serving to bring the issue to

406   the governmental agenda.

407   An indicator of policy image salience and coalescence is if the policy issue is being

408   discussed in formal hearings (Baumgartner and Jones 2010). The first congressional hearing

409   addressing IWPs was conducted in 1999 and addressed issues related to U.S. Department of

410   Agriculture's (USDA) policy for addressing wildlife transmission of diseases to domestic

411   livestock, specifically brucellosis in IWPs (Senate 1999). This has been identified as a

412   potentially significant issue facing agriculture and wildlife management (Miller et al. 2013,

413   Bevins et al. 2014, Miller et al. 2017). However congressional hearings did not begin in earnest

414   until 2005 and 2006 when ten hearings were held – over double from the previous five years.

415   Hearings in these two years were largely related to potential animal agricultural impacts

416   associated with classical swine fever, a swine disease with international trade implications for the

417   U.S. swine industry (Paarlberg et al. 2009). These hearings coincided with a switch in the

418   relative contribution of news media predictors and agriculture to policy activity. Indicating that

419   print news media likely played an important role in forming the IWP policy image early in the

420   policy process but interest groups played a more important role in formulating policies that

421   would be implemented.

422   Once the issue of invasive IWPs was on the policy agenda and policy solutions were

423   being developed, we found that the amount of agriculture in regions with IWPs was the most

424   important predictor of the frequency of policy activity (Figure 4). The relative contribution to

425   policy activity shifted from primarily media related to primarily agricultural after 2006 (see

426   Figure S1.1 and S4). This indicates that agriculture may have been the primary driver influencing

427   the development of potential policy solutions. Investigation of the policy documents revealed

428   that there was an increased focus of IWP policy discourse on agricultural damage concerns

429   indicating that agricultural interests had influence in both setting the policy agenda and the

430   formation of policy solutions. While agriculture contributed relatively small amount to overall

431   policy activity during the problem formation stage prior to policy image coalescence livestock

432   agricultural contributed far greater than crop agriculture (see Figure 3 and panel B in Figure 4).

433   Previous studies have proposed that interest groups that are able to define the problem

434   early in the issue emergence and problem formation stage tend to control future policy

435   development even if new interest groups inter the policy arena (Schattschneider 1960,

436   Baumgartner et al. 2009). Livestock agriculture involvement in policy formation may be driven

437   by the potential for large economic losses – USD$5.8 billion - associated with a single livestock

438   disease outbreak involving IWPs (foot and mouth disease) compared with the currently estimated

439   USD$800 million in crop damage attributed to IWPs (Paarlberg et al. 2002, Pimentel et al. 2002,

440   Pimental 2007, Anderson et al. 2016). Broadly this indicates that those interest groups with the

441   greatest potential risk for damage had the greatest impact on the formation of IWP policy

442   (Baumgartner et al. 2009). This effect may be even greater early in the emergence of an issue

443   when fewer interest groups are involved and the ability for a single group to define the problem

444   and the resulting policy is greater (Schattschneider 1960, Baumgartner et al. 2009).

445   Our approach may provide insights into the drivers of policy activity for wildlife and for

446   invasive species such as feral horses or invasive fish, both of which receive significant media

447   attention, are conflict-ridden, and impact wildlife and agriculture (Kincaid and Fletcher 2017,

448   Kokotovich and Andow 2017). Using our approach for existing policy areas such as these may

449   improve policy maker understanding of the drivers and importance of different interest groups

450   overtime. This can then be used as a tool for improving stakeholder engagement or identifying

451   interest groups that influence policy but have not been formally engaged by policy makers. A

452   potentially more important application of our approach is to newly emerging policy areas in

453   wildlife and invasive species. Early engagement by policy makers can be critical in defining

454   successful policies before a policy area becomes grid locked. In addition, previous research

455   indicates that interests groups whom engage early in a policy area often determine policy

456   outcomes (Sapat 2004). Using our approach in combination with structured decision making

457   techniques (Estévez et al. 2015) or frameworks that identifying stakeholder characteristics and

458   synthesizing public preferences (Sharp et al. 2011) may improve proactive policy development by

459   agencies avoiding policy development that is influenced by a single interest group.

460   This is the first analysis we are aware of that examines the relative contributions of media

461   and institutional pressures on the development of invasive species policies at the Federal scale.

462   In the case of IWPs, our model suggests that changes in co-occurrence of IWPs and agriculture

463   over the last 29 years, likely resulting in increased problem severity (i.e. damage), contributed

464   most to the eventual development of policy to mitigate the problems. This likely resulted from

465   increasing industry pressure on agricultural agencies to protect or mitigate damage associated

466   with IWPs. This was evidenced by both our model predictions and also the amount of

467   consideration given to agricultural damage, specifically damage to livestock, caused by IWPs in

468   congressional hearings and reports (GPO 2001, 2013). Livestock agricultural likely contributed

469   more to the development of policy and has potential implications for implementation of

470   programs to address IWP damage. Given the significant contribution of livestock agriculture to

471   the formation and implementation of policy, national program objectives such as surveillance of

472   IWPs for livestock diseases of concern and mitigation of risks associated with transmission of

473   disease from IWPs to livestock are of particular importance and will require careful planning and

474   implementation.

475   This study is based on a large search of government documents and news media data;

476   therefore there are inherent constraints on inference. While our objective was to investigate the

477   relative contribution of media and institutional pressures on national invasive species policy

478   development, there are other potential drivers of policy activity. Previous studies have found

479   that interest group access to congressional committees and advisory committees are influential in

480   the development of policy (Balla and Wright 2001), although this is also influenced by the

481   number of stakeholders in a policy area (Baumgartner et al. 2009). In our study we only

482   considered three actors – livestock agriculture, crop agriculture, and the public – although there

483   were likely additional actors that contributed to the generation of national policy such as

484   conservation or sportsmen focused interest groups. While IWP policy appears to have gone

485   through a continuum of policy development there is no standard quantitative approach for

486   determining policy phases and investigating other policy processes may be of value. We did not

487   consider policy processes such as policy diffusion (Berry and Berry 1999) or policy

488   entrepreneurs (Mintrom and Norman 2009) that may have influenced national policy activity.

489   These policy processes may also have contributed to the observed policy activity. While our

490   study provides insights into drivers of policy activity addressing the invasive species interface, it

491   could be enhanced by investigating these other mechanisms that may also be important in

492   creation of policy. Additional extensions to our study could investigate the relative contribution

493   of science (e.g. peer reviewed scientific papers) to policy activity compared with interest groups

494   representing agriculture, conservation, and sportsmen. This may be of particular importance to

495   better understand at which policy stage scientific findings have the greatest influence on policy

496   development.

497   Given the scarcity of rigorous quantitative policy work for problems resulting from the

498   interface of invasive species, wildlife, agriculture greater attention is needed to disentangle the

499   mechanisms driving policy development. Although research has examined the influence of

500   media on policy development (Baumgartner and Jones 2010), there remains a lack of information

501   linking measures of public perception and institutional pressures specifically for the interface of

502   wildlife, invasive species, and agricultural. Such information could provide valuable insight into

503   the variability in policy approaches addressing these interactions. Analyses, such as the one we

504   conducted, may provide improved understanding of which stakeholders have contributed most to

505   policy activity and may be especially useful in better understanding complex policy systems.

506   Additionally our approach may also provide early insight into emerging policy areas enabling

507   proactive policy development by agencies or early engagement by scientists to find solutions

508   before the policy area becomes grid locked. In addition linking the results of analyses such as

509   ours with policy and program evaluation could provide a means of determining if the

510   implemented policy and program match the original determinants of the policy. Policy makers

511   can in turn use analyses such as these to better design policies that align with public interests and

512   policy benefactors ensuring long term success of policies by incorporating all interests making

513   programs more effective. (Loomis and Helfand 2001).

514   **Acknowledgements:**

520

521   Literature Cited
522
523   Anderson, A., C. Slootmaker, E. Harper, J. Holderieath, and S. A. Shwiff. 2016. Economic estimates of
524   feral swine damage and control in 11 US states. Crop Protection **89**:89-94.
525   Anderson, J. E. 1984. Public policy and politics in America. Harcourt Brace, New York.
526   Balla, S. J., and J. R. Wright. 2001. Interest groups, advisory committees, and congressional control of the
527   bureaucracy. American Journal of Political Science **45**:799-812.
528   Barbosa, A., J. Brown, and R. Real. 2016. modEvA - An R package for model evaluation and analysis.
529   Barrilleaux, C., C. Reenock, and M. Souva. 2017. Democratic policymaking: an analytic approach.
530   Cambridge University Press.
531   Barrios-Garcia, M. N., and S. A. Ballari. 2012. Impact of wild boar (Sus scrofa) in its introduced and native
532   range: a review. Biological Invasions **14**:2283-2300.
533   Barton, K., and M. K. Barton. 2015. MuMIn - Multi-Model Inference Package. Page 18 Version.
534   Baumgartner, F. R., J. M. Berry, M. Hojnacki, B. L. Leech, and D. C. Kimball. 2009. Lobbying and policy
535   change: Who wins, who loses, and why. University of Chicago Press.
536   Baumgartner, F. R., and B. D. Jones. 1991. Agenda dynamics and policy subsystems. The Journal of
537   Politics **53**:1044-1074.
538   Baumgartner, F. R., and B. D. Jones. 2010. Agendas and instability in American politics. University of
539   Chicago Press.
540   Becker, L. B. 1977. The Impact of Issue Salience.*in* D. L. Shaw and M. E. McCombs, editors. The
541   Emergence of American Political Issues: The Agenda Setting Function of the Press. West
542   Publishing, Saint Paul, MN.
543   Berry, F. S., and W. D. Berry. 1999. Innovation and diffusion models in policy research. Theories of the
544   policy process. Westview Press, Boulder, Colorado.
545   Bevins, S. N., K. Pedersen, M. W. Lutman, T. Gidlewski, and T. J. Deliberto. 2014. Consequences
546   Associated with the Recent Range Expansion of Nonnative Feral Swine. BioScience **64**:291-299.
547   Boyce, M. S., P. R. Vernier, S. E. Nielsen, and F. K. Schmiegelow. 2002. Evaluating resource selection
548   functions. Ecological modelling **157**:281-300.
549   Brewer, G. D., and P. DeLeon. 1983. The foundations of policy analysis. Brooks-Cole Publishing, Pacific
550   Grove, California.
551   Brook, R. K., and F. M. v. Beest. 2014. Feral wild boar distribution and perceptions of risk on the central
552   Canadian prairies. Wildlife Society Bulletin **38**:486-494.
553   Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical
554   information-theoretic approach. Springer.
555   Burnham, K. P., and D. R. Anderson. 2004. Multimodel inference understanding AIC and BIC in model
556   selection. Sociological methods & research **33**:261-304.
557   Burnham, K. P., D. R. Anderson, and K. P. Huyvaert. 2011. AIC model selection and multimodel inference
558   in behavioral ecology: some background, observations, and comparisons. Behavioral Ecology
559   and Sociobiology **65**:23-35.
560   Caplenor, C. A., N. C. Poudyal, L. I. Muller, and C. Yoest. 2017. Assessing landowners' attitudes toward
561   wild hogs and support for control options. Journal of Environmental Management **201**:45-51.
562   Centner, T. J., and R. M. Shuman. 2015. Governmental provisions to manage and eradicate feral swine in
563   areas of the United States. Ambio **44**:121-130.
564   Corn, J. L., and T. R. Jordan. Development of the National Feral Swine Map, 1982–2016. Wildlife Society
565   Bulletin **41**:758-763.

566   Crowley, S. L., S. Hinchliffe, and R. A. McDonald. 2017. Conflict in invasive species management.
567   Frontiers in Ecology and the Environment **15**:133-141.
568   Dodds, P. S., E. M. Clark, S. Desu, M. R. Frank, A. J. Reagan, J. R. Williams, L. Mitchell, K. D. Harris, I. M.
569   Kloumann, and J. P. Bagrow. 2015. Human language reveals a universal positivity bias.
570   Proceedings of the National Academy of Sciences **112**:2389-2394.
571   Dodds, P. S., K. D. Harris, I. M. Kloumann, C. A. Bliss, and C. M. Danforth. 2011. Temporal patterns of
572   happiness and information in a global social network: Hedonometrics and Twitter. PloS one
573   **6**:e26752.
574   EBSCO. 2016. EBSCO Newspaper Source Database.
575   Elder, R. W., and C. D. Cobb. 1983. Participation in American politics: The dynamics of agenda-building.
576   Page 196. John Hopkins University Press, Baltimore, Maryland.
577   Entman, R. M. 1993. Framing: Towards clarification of a fractured paradigm. McQuail's reader in mass
578   communication theory **43**:390-397.
579   Estévez, R. A., C. B. Anderson, J. C. Pizarro, and M. A. Burgman. 2015. Clarifying values, risk perceptions,
580   and attitudes to resolve or avoid social conflicts in invasive species management. Conservation
581   Biology **29**:19-30.
582   Funkhouser, G., and E. F. Shaw. 1990. How synthetic experience shapes social reality. Journal of
583   communication **40**:75-87.
584   Gilliam Jr, F. D., and S. Iyengar. 2000. Prime suspects: The influence of local television news on the
585   viewing public. American Journal of Political Science **44**:560-573.
586   GPO. 2001. Agriculture, Rural Development, Food And Drug Administration, And Related Agencies
587   Appropriations for 2001. Page 461 Subcommittee on Agriculture, Rural Development, Food and
588   Drug Administration, and Related Agencies. U.S. Government Printing Office.
589   GPO. 2013. Agriculture, Rural Development, Food And Drug Administration, And Related Agencies
590   Appropriations for 2014. Page 487 Subcommittee on Agriculture, Rural Development, Food and
591   Drug Administration, and Related Agencies. U.S. Government Printing Office.
592   GPO. 2014. Federal Digital System (FDsys). United States Government Printing Office.
593   Group', W. H. W. 2016. 2016 Annual State Summary Report: Wild Hog Working Group. Southeastern
594   Association of Fish and Game Agencies.
595   Guisan, A., and N. E. Zimmermann. 2000. Predictive habitat distribution models in ecology. Ecological
596   modelling **135**:147-186.
597   Hanson, R., and L. Karstad. 1959. Feral swine in the southeastern United States. The Journal of wildlife
598   management **23**:64-74.
599   Hu, M., and B. Liu. 2004. Mining and summarizing customer reviews. Pages 168-177 *in* Proceedings of
600   the tenth ACM SIGKDD international conference on Knowledge discovery and data mining. ACM.
601   Huberty, C. J. 1994. Applied discriminant analysis. Wiley New York.
602   Izac, A., and P. O'Brien. 1991. Conflict, uncertainty and risk in feral pig management Australian
603   approach. Journal of Environmental Management **32**:1-18.
604   Jones, B. A., D. Grace, R. Kock, S. Alonso, J. Rushton, M. Y. Said, D. McKeever, F. Mutua, J. Young, and J.
605   McDermott. 2013. Zoonosis emergence linked to agricultural intensification and environmental
606   change. Proceedings of the National Academy of Sciences **110**:8399-8404.
607   Jones, B. D., and F. R. Baumgartner. 2004. Representation and agenda setting. Policy Studies Journal
608   **32**:1-24.
609   Keiter, D. A., J. J. Mayer, and J. C. Beasley. 2016. What is in a "common" name? A call for consistent
610   terminology for nonnative Sus scrofa. Wildlife Society Bulletin **40**:384-387.

611   Kincaid, A. T., and A. J. Fletcher. 2017. Policy problems, publics, and the power of definition: Competing
612   discourses and the case of Alberta's free-roaming horses. The Canadian Geographer/Le
613   Géographe canadien **61**:360-374.
614   Kingdon, J. W., and J. A. Thurber. 1984. Agendas, alternatives, and public policies. Little, Brown and
615   Company, Boston.
616   Kleinbaum, D., L. Kupper, A. Nizam, and E. Rosenberg. 2013. Applied regression analysis and other
617   multivariable methods. Nelson Education.
618   Koch-Baumgarten, S., and K. Voltmer. 2010. Public Policy and the Mass Media: The Interplay of Mass
619   Communication and Political Decision Making. Routledge.
620   Kohavi, R. 1995. A study of cross-validation and bootstrap for accuracy estimation and model selection.
621   International Joint Conference on Artificial Intelligence **14**:1137-1145.
622   Kokotovich, A. E., and D. A. Andow. 2017. Exploring tensions and conflicts in invasive species
623   management: The case of Asian carp. Environmental Science & Policy **69**:105-112.
624   Krebs, J., R. Anderson, T. Clutton-Brock, C. Donnelly, S. Frost, W. Morrison, R. Woodroffe, and D. Young.
625   1998. Badgers and bovine TB: conflicts between conservation and health. Science **279**:817-818.
626   LexisNexis. 2016. LexisNexis Academic Database.
627   Liu, B. 2015. Sentiment Analysis: Opinions, Sentiment, and Emotion in Text. Cambridge University Press.
628   Lodge, M., and K. Matus. 2014. Science, badgers, politics: Advocacy coalitions and policy change in
629   bovine tuberculosis policy in Britain. Policy Studies Journal **42**:367-390.
630   Loomis, J., and G. E. Helfand. 2001. Environmental policy analysis for decision making. Kluwer Academic
631   Amsterdam,, Netherlands, New York, New York.
632   Mayer, J., and I. Brisbin. 1991. Wild pigs in the United States: their life history, morphology and current
633   status. University of Georgia Press. Athens, Georgia, USA.
634   McBeth, M. K., and E. A. Shanahan. 2004. Public opinion for sale: The role of policy marketers in Greater
635   Yellowstone policy conflict. Policy Sciences **37**:319-338.
636   McClure, M. L., C. L. Burdett, M. L. Farnsworth, M. W. Lutman, D. M. Theobald, P. D. Riggs, D. A. Grear,
637   and R. S. Miller. 2015. Modeling and mapping the probability of occurrence of invasive wild pigs
638   across the contiguous United States. PloS one **10**:e0133771.
639   McClure, M. L., C. L. Burdett, M. L. Farnsworth, S. J. Sweeney, and R. S. Miller. 2018. A globally-
640   distributed alien invasive species poses risks to United States imperiled species. Scientific
641   Reports.
642   McCombs, M. E., and D. L. Shaw. 1972. The agenda-setting function of mass media. Public opinion
643   quarterly **36**:176-187.
644   Messmer, T. A. 2009. Human–wildlife conflicts: emerging challenges and opportunities. Human-Wildlife
645   Conflicts **3**:10-17.
646   Michel, N. L., M. P. Laforge, F. M. Van Beest, and R. K. Brook. 2017. Spatiotemporal trends in Canadian
647   domestic wild boar production and habitat predict wild pig distribution. Landscape and Urban
648   Planning **165**:30-38.
649   Miller, R. S., M. L. Farnsworth, and J. L. Malmberg. 2013. Diseases at the livestock–wildlife interface:
650   Status, challenges, and opportunities in the United States. Preventive veterinary medicine
651   **110**:119-132.
652   Miller, R. S., and S. J. Sweeney. 2013. Mycobacterium bovis (bovine tuberculosis) infection in North
653   American wildlife: current status and opportunities for mitigation of risks of further infection in
654   wildlife populations. Epidemiology and infection **141**:1357-1370.
655   Miller, R. S., S. J. Sweeney, C. Slootmaker, D. A. Grear, P. A. Di Salvo, D. Kiser, and S. A. Shwiff. 2017.
656   Cross-species transmission potential between wild pigs, livestock, poultry, wildlife, and humans:
657   implications for disease risk management in North America. Scientific Reports **7**.

658   Mintrom, M., and P. Norman. 2009. Policy entrepreneurship and policy change. Policy Studies Journal
659   **37**:649-667.
660   NewsBank. 2016. NewsBank NewsFile Collection. NewsBank.
661   Paarlberg, P. L., J. G. Lee, and A. H. Seitzinger. 2002. Potential revenue impact of an outbreak of foot-
662   and-mouth disease in the United States. Journal of the American Veterinary Medical Association
663   **220**:988-992.
664   Paarlberg, P. L., A. H. Seitzinger, J. G. Lee, and K. Mathews. 2009. Supply reductions, export restrictions,
665   and expectations for hog returns in a potential classical swine fever outbreak in the United
666   States. Journal of swine health and production **17**:155-162.
667   Paini, D. R., A. W. Sheppard, D. C. Cook, P. J. De Barro, S. P. Worner, and M. B. Thomas. 2016. Global
668   threat to agriculture from invasive species. Proceedings of the National Academy of Sciences
669   **113**:7575-7579.
670   Pimental, D. 2007. Environmental and economic costs of vertebrate species invasions into the United
671   States. Pages 2-8 *in* Proceedings of an International Symposium: Managing Vertebrate Invasive
672   Species, US Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife
673   Services, National Wildlife Research Center.
674   Pimentel, D., L. Lach, R. Zuniga, and D. Morrison. 2002. Environmental and economic costs associated
675   with non-indigenous species in the United States. Pages 285-303 Biological Invasions: Economic
676   and Environmental Costs of Alien Plant, Animal, and Microbe Species. CRC Press, New York.
677   ProQuest. 2016. ProQuest Newspaper Database.
678   R Core Team. 2016. R: A language and environment for statistical computing. R foundation for Statistical
679   Computing, Vienna, Austria.
680   Rinker, T. W. 2013. qdap: Quantitative Discourse Analysis Package. version 1.3.6., University at Buffalo.
681   Buffalo, New York.
682   Sabatier, P. A., and C. M. Weible. 2014. Theories of the policy process. Avalon Publishing, New York,
683   New York.
684   Sapat, A. 2004. Devolution and innovation: The adoption of state environmental policy innovations by
685   administrative agencies. Public Administration Review **64**:141-151.
686   Schattschneider, E. E. 1960. The Semisovereign People: A Realist's View of Democracy in America. Holt,
687   Rinehart, and Winston, New York.
688   Schnell, K. C., Frauke. 2001. Assessing the democratic debate: How the news media frame elite policy
689   discourse. Political communication **18**:183-213.
690   SCWDS. 2013. National Feral Swine Distribution Maps.*in* National Feral Swine Mapping System, editor.
691   Southeastern Cooperative Wildlife Disease Study, University of Georgia, Athens, GA.
692   Senate. 1999. Agriculture, rural development, and related agencies appropriations for fiscal year 2000.
693   Page 1433 *in* U. S. Senate, editor. Subcommittee of the Committee on Appropriations United
694   States Senate. U.S. Government Printing Office, Washington D.C.
695   Sharp, R. L., L. R. Larson, and G. T. Green. 2011. Factors influencing public preferences for invasive alien
696   species management. Biological Conservation **144**:2097-2104.
697   Snow, N. P., M. A. Jarzyna, and K. C. VerCauteren. 2017. Interpreting and predicting the spread of
698   invasive wild pigs. Journal of Applied Ecology **54**:2022-2032.
699   Soroka, S. N. 2003. Media, public opinion, and foreign policy. The International Journal of Press/Politics
700   **8**:27-48.
701   Tisdell, C. A. 1982. Wild pigs: environmental pest or economic resource. Pergamon Press Ltd.
702   Turbelin, A. J., B. D. Malamud, and R. A. Francis. 2017. Mapping the global state of invasive alien species:
703   patterns of invasion and policy responses. Global Ecology and Biogeography **26**:78-92.

704 USDA. 2013. Environmental Impact Statement; Feral Swine Damage Management.*in* USDA, editor. 78 FR
705   27937. Office of the Federal Register, National Archives and Records Administration, Federal
706   Register Volume 78, Issue 92.
707 USDA. 2014. Quick stats. National Agricultural Statistics Service, US Department of Agriculture,
708   Washington, DC.
709 Valliant, R., J. A. Dever, and F. Kreuter. 2013. Practical tools for designing and weighting survey samples.
710   Springer.
711 Waithman, J. D., R. A. Sweitzer, D. Van Vuren, J. D. Drew, A. J. Brinkhaus, I. A. Gardner, and W. M. Boyce.
712   1999. Range expansion, population sizes, and management of wild pigs in California. The Journal
713   of wildlife management **63**:298-308.
714 Walgrave, S., S. Soroka, and M. Nuytemans. 2008. The Mass Media's Political Agenda-Setting Power A
715   Longitudinal Analysis of Media, Parliament, and Government in Belgium (1993 to 2000).
716   Comparative Political Studies **41**:814-836.
717 Weart, S. 1988. Nuclear Fear: A history of images Harvard university Press, Cambridge, MA.
718 Weisberg, S. 2005. Applied linear regression. John Wiley & Sons.

719
720

721   **TABLES:**

722   **Table 1.** Candidate models use to estimate the county scale co-occurrence of invasive wild pigs and
723   agricultural producers that was used as a predictor in the policy models. The best approximating model in
724   the candidate set of models was a logistic model and had good predictive capacity with an adjusted $R^2 =$
725   0.99.
726
727   **Table 2.** Candidate set of models used in the model averaging procedure to generate the final inferential
728   model. These eight models account for 99.9% of the AICc weight given the candidate set of 64 models.
729   The null model (intercept only) was ranked as the least informative model and the top model was 485
730   AICc units better (i.e. lower) than the null model suggesting the selected covariates approximated the data
731   well.
732
733   **Table 3.** Model-averaged parameter estimates for the final inferential model describing the relationship
734   between invasive wild pig policy activity, news media, and the amount of agriculture co-occurring with
735   invasive wild pigs.
736

737   **Table 1.** Candidate models use to estimate the county scale co-occurrence of invasive wild pigs and
738   agricultural producers that was used as a predictor in the policy models. The best approximating model in
739   the candidate set of models was a logistic model and had good predictive capacity with an adjusted R^2 =
740   0.99.

Candidate Models	df	AICc	Δ AICc	Aikaike Weight	Adjusted R^2
Logistic	7	-58.04	0.00	7.63×10^1	0.99
Linear	7	-36.31	21.73	1.46×10^5	0.92
Exponential	7	-27.74	30.30	2.01×10^7	0.99
Power	7	-27.16	30.88	1.51×10^7	0.99

741

742 **Table 2.** Candidate set of models used in the model averaging procedure to generate the final inferential model. These eight models account for
743 99.9% of the AICc weight given the candidate set of 64 models. The null model (intercept only) was ranked as the least informative model and the
744 top model was 485 AICc units better (i.e. lower) than the null model suggesting the selected covariates approximated the data well.
745

Model							K	Δ AICc	AICc Weight
Intercept	Agriculture			# States	Article Tone	Source Tone	5	0.00	0.313
Intercept	Agriculture	# Articles	# Sources	# States	Article Tone		6	0.70	0.221
Intercept	Agriculture	# Articles		# States	Article Tone	Source Tone	6	0.89	0.201
Intercept	Agriculture		# Sources	# States	Article Tone	Source Tone	6	1.74	0.131
Intercept	Agriculture	# Articles	# Sources	# States	Article Tone	Source Tone	7	2.68	0.082
Intercept	Agriculture			# States	Article Tone		4	5.40	0.021
Intercept	Agriculture	# Articles	# Sources	# States			5	5.61	0.019
Intercept	Agriculture	# Articles		# States	Article Tone		5	6.55	0.012

746

747
748

749 **Table 3.** Model-averaged parameter estimates for the final inferential model describing the relationship between invasive wild pig policy activity,
750 news media, and the amount of agriculture co-occurring with invasive wild pigs.

| Parameter	Odds Ratio	Estimate	Unconditional Standard Error	Unconditional Confidence Interval		AICc Weight
				2.5%	97.5%	
All agriculture	4.09	1.41	0.25	1.32	1.50	1
Livestock agriculture	4.08	1.41	0.34	1.32	1.49	1
Crop agriculture	3.43	1.23	0.53	0.96	1.51	0.92
# States with news media	2.08	0.73	0.17	0.69	0.78	1
Newspaper article tone	1.95	0.67	0.23	0.59	0.75	0.98
Media source tone	1.14	0.13	0.08	0.11	0.15	0.73
# Newspaper articles	1.98	0.68	1.04	-0.88	2.25	0.53
# Media Sources	0.53	-0.64	1.36	-2.72	1.44	0.46

751

752

753   **FIGURES:**

754   **Figure 1.** Congressional policy activity and major policy milestones for invasive wild pigs from 1985
755   through 2013. Blue colors represent regulatory policy activity associated with changes to the code of federal
756   regulations and federal register. Yellow and orange colors represent the agenda setting policy stage and
757   include activity associated with congressional hearings, reports, and record. Red indicates the policy
758   formation and implementation stage and includes bills addressing invasive wild pig policy.
759

760
761
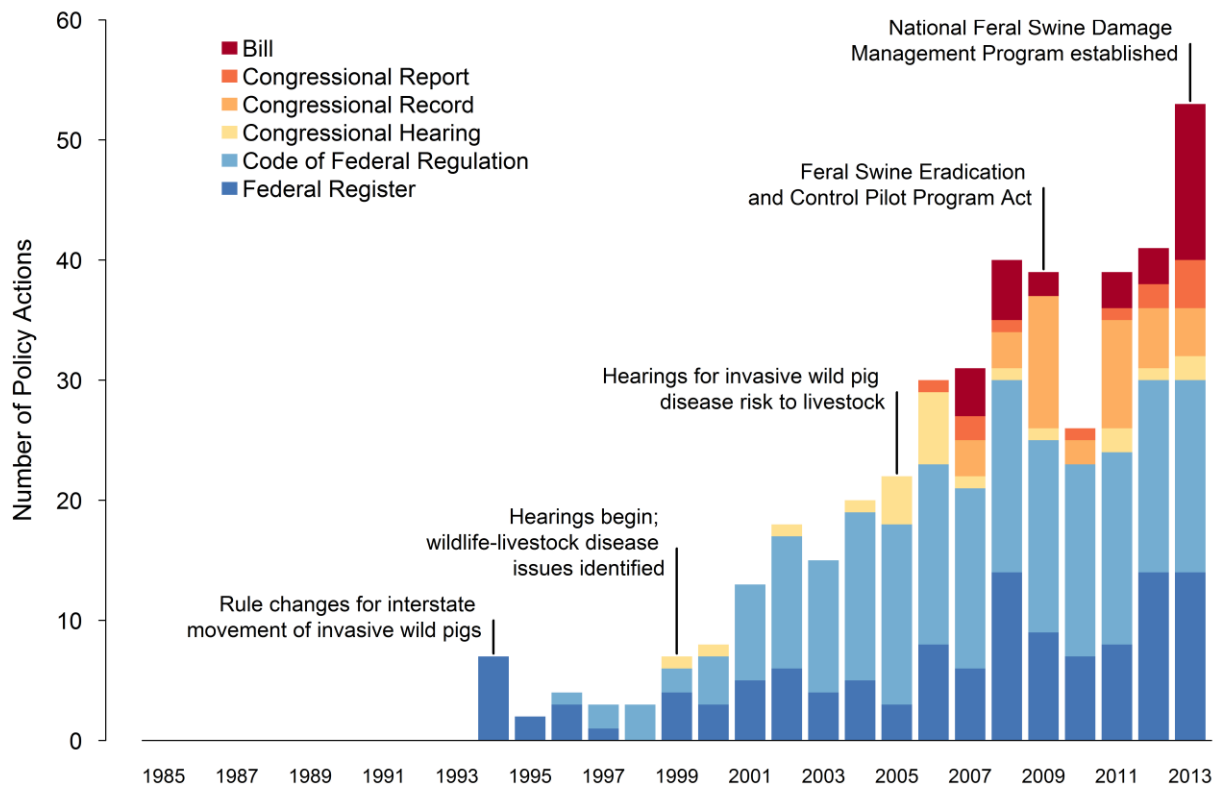
762   **Figure 2.** Change in distribution of invasive wild pigs and co-occurrence with agriculture in the United
763   States. Panel A illustrate the change in the geographic distribution of invasive wild pigs in the United States.
764   Years indicate the first year invasive wild pigs were identified within the county based on the SCWDS data.
765   Blue scaled colors represent 'historical' range from 1959 until 1988. Yellow and orange scaled colors
766   represent 'contemporary' range from 2004 until 2013. Panel B reports the increase in county level co-
767   occurrence of invasive wild pigs and agriculture. Circles represent observed proportion of counties in the
768   United States in which invasive wild pigs and agriculture co-occur. Black line (solid and dotted) denotes
769   logistic model estimated mean and gray band is the 95% prediction interval. Solid line indicates the
770   estimated mean used as a predictor for the years of our study – 1985 to 2013. The annual rate of increase was
771   estimated as 1.01 (stdev <0.01) from 1959 to 2013 with the estimated inflection year being 2034 with 69.9%
772   of agriculture co-occurring with invasive wild pigs. The model had good predictive capacity having an
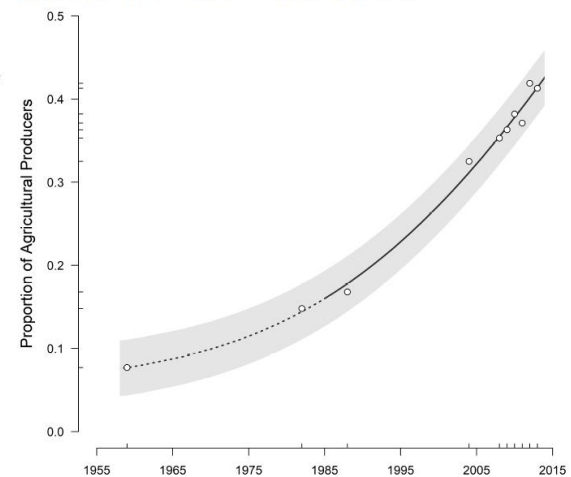773   adjusted R^2 = 0.99.

774

775
776
777
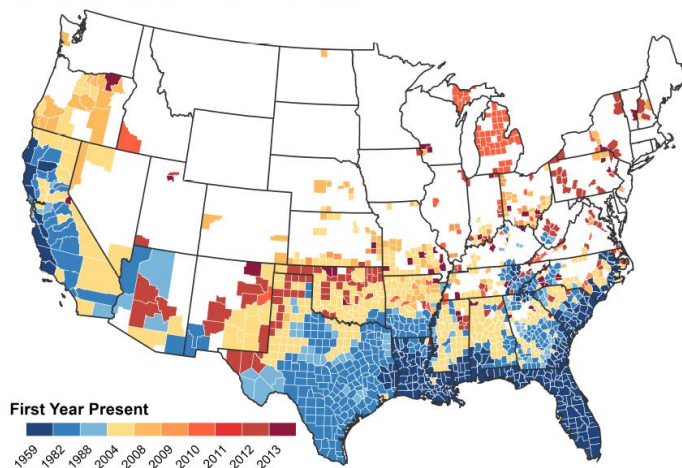
778 **Figure 3.** Mean functional relationship between invasive wild pig congressional policy activity and the
779 national proportion of agriculture co-occurring invasive wild pigs in the United States. Solid black line
780 indicates predicted mean relationship and gray band indicates unconditional 95% confidence interval. Panels
781 represent the functional relationship for (A) all invasive wild pig policy activity, (B) invasive wild pig policy
782 activity specific to livestock agriculture, and (C) invasive wild pig policy activity specific to crop agriculture.
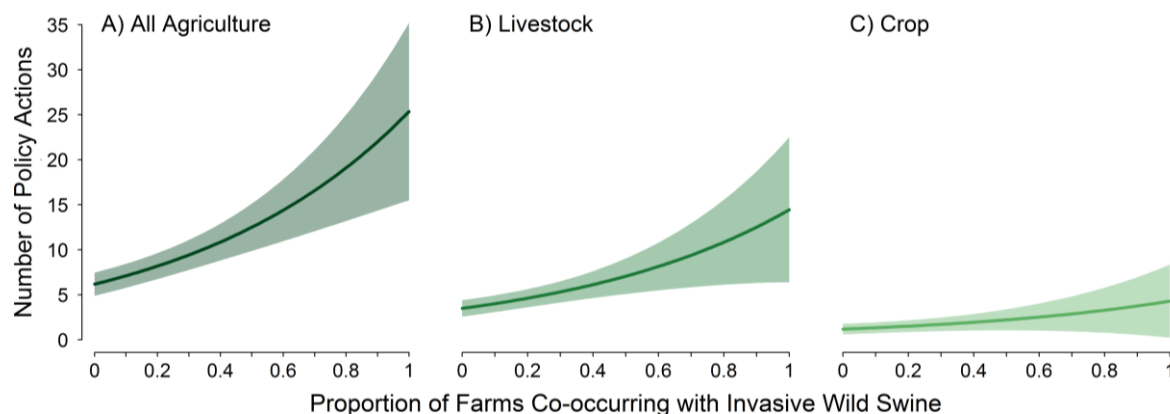

783

784

785

786

787   **Figure 4.** The model predicted change in relative contribution of predictors to annual policy activity for
788   invasive wild pigs. Panel A contrasts the changes in the annual contribution of agriculture, article and
789   newspaper tone, and number of states with newspaper articles. Panel B describes the relative contribution of
790   livestock and crop specific activity to overall invasive wild pig policy. Solid lines indicate mean contribution
791   and shaded region represents 95% confidence interval.

792