

Data contradict common perceptions about a controversial provision of the US Endangered Species Act

Jacob W. Malcom¹ and Ya-Wei Li

Defenders of Wildlife Endangered Species Conservation Program, Washington, DC 20036

Edited by Michael Kraft, University of Wisconsin, Green Bay, WI, and accepted by the Editorial Board October 30, 2015 (received for review August 25, 2015)

Separating myth and reality is essential for evaluating the effectiveness of laws. Section 7 of the US Endangered Species Act (Act) directs federal agencies to help conserve threatened and endangered species, including by consulting with the US Fish and Wildlife Service (FWS) or National Marine Fisheries Service on actions the agencies authorize, fund, or carry out. Consultations ensure that actions do not violate the Act's prohibitions on "jeopardizing" listed species or "destroying or adversely modifying" these species' critical habitat. Because these prohibitions are broad, many people consider section 7 the primary tool for protecting species under the Act, whereas others believe section 7 severely impedes economic development. This decades-old controversy is driven primarily by the lack of data on implementation: past analyses are either over 25 y old or taxonomically restricted. We analyze data on all 88,290 consultations recorded by FWS from January 2008 through April 2015. In contrast to conventional wisdom about section 7 implementation, no project was stopped or extensively altered as a result of FWS finding jeopardy or adverse modification during this period. We also show that median consultation duration is far lower than the maximum allowed by the Act, and several factors drive variation in consultation duration. The results discredit many of the claims about the onerous nature of section 7 but also raise questions as to how federal agencies could apply this tool more effectively to conserve species. We build on the results to identify ways to improve the effectiveness of consultations for imperiled species conservation and increase the efficiency of consultations.

Endangered Species Act | section 7 consultation | imperiled species | US Fish and Wildlife Service

Without accurate information about how the government implements a law, public perceptions of the law may be driven by anecdotes, unsupported generalizations, or misinformation. Controversial laws may be particularly susceptible to this problem because inaccurate information can solidify deeply held beliefs about those laws, impeding efforts to ground legal reforms in science. Advances in data analytics are helping to overcome these problems by enabling researchers to systematically analyze how laws are actually implemented. By distinguishing perception from reality, researchers can offer novel insights on how to more effectively administer laws (1–3). Some of the most controversial aspects of biodiversity laws, however, have rarely been systematically evaluated, despite polarized public opinion on those laws.

In 1973, President Richard Nixon signed into law the US Endangered Species Act (Act) in response to the growing number of species threatened with extinction. The Act remains the premier law for protecting the 1,591 species listed as threatened or endangered in the US and their habitat (https://ecos.fws.gov/tess_public/pub/boxScore.jsp). Because the Act has the power to regulate many land use activities, some lawmakers and industries have sought to weaken or overturn the Act since shortly after its passage. The rhetoric surrounding these proposals often focuses on proposed projects being stopped or severely delayed by the Act (4). Attempts to legislatively undermine the Act have never been more numerous: the 114th Congress has thus far introduced more than 80 bills or

amendments to reduce or remove the protections of the Act, such as the National Defense Authorization Act (5). Many of the proposals target section 7 of the Act (Box 1) because it contains some of the strictest prohibitions in the law—at least on paper.

Conservationists often tell a different narrative about section 7. These individuals argue that federal agencies are failing to strictly apply section 7 prohibitions in the face of increasing pressure to minimize the economic impacts of protecting wildlife (6). Massive infrastructure projects are authorized with inadequate conservation requirements, whereas thousands of smaller projects fragment and erode habitat in ways that are rarely tracked (7). Gone are the days when section 7 made national headlines because it restricted the logging of old-growth forests or halted the completion of a \$100 million dam on the Little Tennessee River. These arguments suggest that the section 7 of today is a paper tiger, leaving many species vulnerable to further habitat loss and diminished chances of recovery.

Despite these conflicting storylines about section 7, there have been very few systematic analyses of the tool. The US House of Representatives report to Congress on the 1982 amendments to the Act considered 8,817 informal and 1,945 formal FWS consultations from 1979 to 1981 (8). The report found 192 (1.8%) consultations resulted in jeopardy and only two projects were stopped, partly because of the Act (8, 9). A white paper from World Wildlife Fund (10) examined 71,560 informal and 2,000 formal FWS consultations from 1987 to 1991 and found that only 350 (0.47%) consultations resulted in jeopardy. Of those projects, only 18 (0.02%) were blocked or cancelled because of section 7. Owen (11) analyzed 4,048 biological opinions for fish species from both Services between 2005 and 2009 and found that jeopardy and destruction/adverse modification conclusions were rare (7.2% and 6.7% of formal consultations, respectively). Thus, our current

Significance

The US Endangered Species Act is the most comprehensive law any nation has enacted to protect imperiled species. Many of its protections come from section 7 of the Act, but how government regulators use this tool is poorly understood. Our analysis is the first to systematically evaluate how the US Fish and Wildlife Service has implemented section 7 over an extend timeframe and across all listed species. The results inform current efforts to improve the conservation effectiveness of section 7 and rebut certain claims about the regulatory burdens of complying with section 7.

Author contributions: J.W.M. and Y.-W.L. designed research, performed research, analyzed data, and wrote the paper.

Conflict of interest statement: The authors are employed by Defenders of Wildlife; the results do not necessarily reflect the positions of Defenders of Wildlife.

This article is a PNAS Direct Submission. M.K. is a guest editor invited by the Editorial Board.

Data deposition: The code for the application used in the analyses available at GitHub (https://github.com/Defenders-ESC/section7_explorer). The data is available both from the GitHub repository and from within the web application.

¹To whom correspondence should be addressed. Email: jmalcom@defenders.org.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1516938112/-DCSupplemental.

Box 1: Overview of section 7 consultations and key terms

Section 7 of the Act requires all federal agencies to ensure that the actions they fund, authorize, or carry out are not likely to “jeopardize” a species or “destroy or adversely modify” critical habitat. Federal agencies must consult with the US Fish and Wildlife Service (FWS) or the National Marine Fisheries Service (NMFS) to fulfill this mandate. Consultations typically start as discussions between the Service and a federal agency to determine whether the agency’s proposed actions may affect a listed species. How FWS biologists are assigned to consultations varies by field office: in some cases, species experts take the lead; in other cases, biologists cover specific geographic areas or particular activities. This “informal consultation” ends if the Service determines that the activity is “not likely to adversely affect” a species. Otherwise, “formal consultation” is required. During formal consultation, the Service evaluates whether the proposed action will violate the prohibitions on jeopardy or destruction/adverse modification. If neither of these outcomes is likely but take is expected, then the Service will prescribe “reasonable and prudent measures” (RPMs) that are designed to minimize the effects of the action and the amount of take. If either jeopardy or destruction/adverse modification is likely, the Service must suggest “reasonable and prudent alternatives” (RPAs)—conservation measures that reduce or partly offset the harm from the proposed action, to avoid jeopardy or adverse modification. If no such alternatives are available, the action cannot proceed without violating the Act unless it is exempted by a special committee known as the “God Squad.” Formal consultations end with a Service “biological opinion,” which must be finalized within 135 d after formal consultation begins, unless an extension is agreed on.

knowledge of how the Services implement section 7 is based on dated or taxonomically restricted research.

To illustrate how administrative data can provide novel insights on the implementation of a polarizing law, we analyze the results of all section 7 consultations recorded by FWS from 2008 through April 2015. We obtained the records for these consultations from FWS’s Tracking and Integrated Logging System (TAILS) database and verified questionable entries by reviewing original documents. Using this data (described in detail in *Materials and Methods*) we find that, unlike during previous decades, no project has been stopped or extensively altered as a result of FWS concluding either jeopardy or destruction/adverse modification of critical habitat. We also find that the median duration of formal consultations is well within the maximum timeframe allowed by the Act. We discuss how these results can help identify opportunities to improve the efficiency of consultations without sacrificing their effectiveness at conserving species. Lastly, we describe a web application that allows any interested user, from citizens to lawmakers, to explore the consultation data in detail.

Results

The TAILS database shows that 1,394 FWS biologists ($\bar{x} = 602$ biologists per year; range, 379–690) recorded 81,461 informal and 6,829 formal consultations from January 2008 through April 2015 (Fig. 1A). These numbers exclude 110,850 consultations recorded as technical assistance over the same time period. At the national level, the number of both formal and informal consultations has declined through time (mean change per year, $-1,057.7$ consultations, $SE = 259.6$; $F = 16.6$, $df = 1,6$, $P = 0.0065$), but that decline is not always present at smaller scales, such as individual FWS field offices (e.g., North Dakota Ecological Services Field Office; Fig. 1B). The characteristics of consultations are spatially structured: although most consultations occur in the eastern United States (Fig. 2A), formal consultations are much more common in the west (Fig. 2B). The most commonly consulted-on species is the Indiana bat

(*Myotis sodalis*; Fig. 3A, the most commonly consulting agency is the Army Corps of Engineers (Fig. 3B), and the most common category of activity requiring consultation is “development” (Fig. 3C). We estimate that only 3,454 (3.9%) consultations during the period were for conservation actions such as habitat restoration.

Of the 6,829 (7.7%) formal consultations, only two (0.0023%) resulted in jeopardy, one of which also resulted in destruction/adverse modification of critical habitat. That consultation covered a US Forest Service proposal to apply fire retardants on national forests and resulted in jeopardy and/or destruction/adverse modification for 45 species. The biological opinion for that consultation was rejected by a court and redone in 2011; the revised consultation concluded no jeopardy or destruction/adverse modifications. The only remaining consultation with a jeopardy conclusion focused on the effects to the delta smelt (*Hypomesus transpacificus*) from a water management project in California’s Central Valley. Even that project, however, was allowed to proceed if the permittees adopted RPAs to minimize and partially offset the adverse effects of the project.

The median duration of informal consultations was 13 d [approximate 95% confidence interval (CI) = 12–13 d], and the median duration of formal consultations was 62 d (approximate 95% CI = 60–65 d; range, 1–4,426 d). The median duration of programmatic consultations, which are consultations on plans, programs, or regulations that authorize future actions, was 13 d ($n = 3,092$; approximate 95% CI = 10–16 d) for informal consultations and 82 d for formal ($n = 1,142$; approximate 95% CI = 62–107 d). In many instances, those future actions require their own consultation, which lasted 17 d ($n = 2,401$; approximate 95% CI = 17–18) and 24 d ($n = 845$; approximate 95% CI = 21–27) for informal and formal consultations, respectively. The durations of 1,381 formal consultations were longer than the 135-d limit prescribed in Services regulations absent an extension approved by the consulting agency (20% of formal). Of these, FWS had marked 1,297 consultations as not being completed on time, indicating ~100 consultations were completed under a mutually agreed extension. We observed significant variation in the duration of formal consultations among FWS regional offices ($F = 27.77$; $df = 8$ and 6,112; $P < 2.2 \times 10^{-16}$), with more formal consultations generally corresponding to longer average duration. Beyond simple descriptive statistics of consultation duration, we also sought to explain why the duration varies. Using regression analysis (*Materials and Methods*), we found that the best predictors of variation in duration were whether the consultations were formal, the identity of the FWS biologist performing the consultation, and the number of species evaluated in the consultation. Although the identity of the lead biologist had the

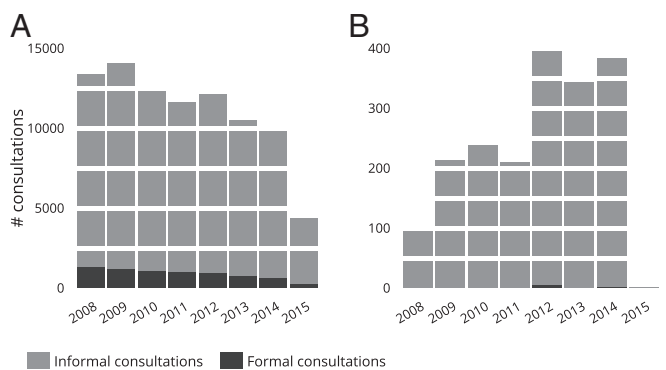


Fig. 1. The numbers of both informal and formal consultations have declined nationally since 2008 (A), but local trends reflect changing local activities, such as oil and gas development in North Dakota (B). The decline in both informal and formal consultations at the national level is statistically significant at $\alpha < 0.01$. The surge in consultations in North Dakota is driven by consultations for oil and gas development plus related infrastructure, including housing, roads, and communications (e.g., cell towers).

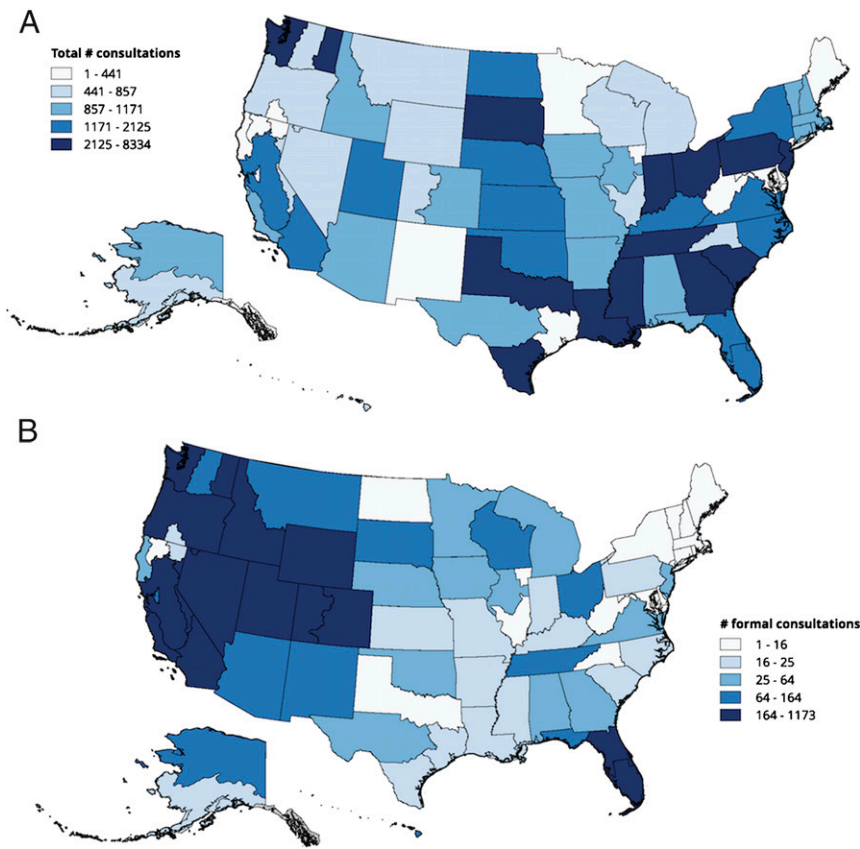


Fig. 2. Although the majority of consultations occur in the eastern United States (A), formal consultations are concentrated in the western states (B). Exceptions to the pattern exist, such as the high number of consultations in eastern and western Washington, and the high number of formal consultations in Florida. In addition to state boundaries, the maps show approximate boundaries for FWS Ecological Services field offices (i.e., the area covered by each office). Five states (Vermont, New Hampshire, Massachusetts, Rhode Island, and Connecticut) are covered by the New England Field Office. All of Iowa and part of Illinois are covered by the Rock Island Field Office. Choropleth divisions are based on quantiles.

largest sum of squares, whether consultations were formal had the largest mean square (Table 1); formal consultations add an estimated 43.8 d (SE = 0.436) to consultation duration. TAILS does not include data on the quality, comprehensiveness, or scope (e.g., area affected by the action) of the consultations, each of which can affect the duration.

Educating policy makers and the public is key to improving policy implementation. To that end, we created a web-based application that allows users to explore our version of the TAILS database, which corrected for errors we found in the FWS dataset (defenders.org/section7; also see *Materials and Methods*). After selecting a state, species, or any of 10 other variables of interest, the application generates interactive plots and maps to visualize the results. The application also allows users to run two separate searches simultaneously and compare the results. Any of the TAILS data can be downloaded by users for additional analyses; the only data-masking we applied was hashing the names of the FWS biologists to protect their identity while still allowing future analyses to consider biologist identity as a covariate.

Discussion

Deciding policy based on anecdote rather than comprehensive data are fraught with problems. The Act is widely considered the strongest law in the world for protecting imperiled species and their habitat (12), but little is known about how federal agencies actually implement one of the most important provisions of the law—section 7 consultations. As a result, some view implementation as a significant hindrance to economic development (13, 14) while others view it as not halting or modifying enough development projects that harm listed species. Using data that span all consultations recorded by FWS since 2008, we show that FWS very rarely concludes jeopardy or destruction/adverse modification and that the median duration of formal consultations is far below the statutory limit. The first result questions the extent to which consultations are adequately protecting species, and both results counter many of the claims about the regulatory burdens and delays of complying with section 7.

None of the 88,290 actions consulted on with FWS during the past 7 y has been stopped or extensively altered as a result of FWS finding jeopardy or destruction/adverse modification. After considering court-ordered revisions of one consultation,

Table 1. Whether consultations are formal or informal explains more variation in consultation duration than any other variable examined

Predictor variable	df	SS	MS	F	P (>F)
Lead biologist	1,233	20,890,804	16,943	26.905	$<2 \times e^{-16}$
Formal consultation (true)	1	6,428,433	6,428,433	10,208.088	$<2 \times e^{-16}$
Fiscal year	7	40,640	5,806	9.219	$1.88 \times e^{-11}$
Number species evaluated	1	10,5127	105,127	166.937	$<2 \times e^{-16}$
Consultation complexity	3	190,026	63,342	100.585	$<2 \times e^{-16}$
Action category	91	338,187	3,716	5.901	$<2 \times e^{-16}$
Residuals	84,485	53,203,515	630		

SS, sum of squares; MS, mean square.

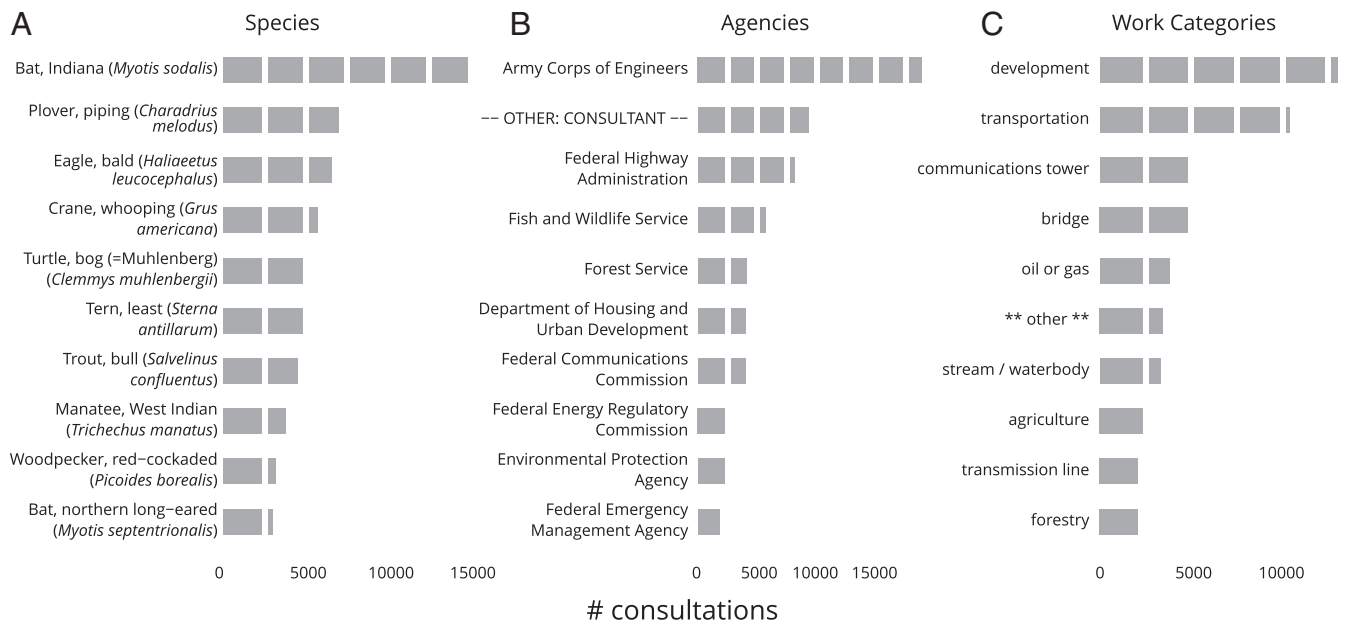


Fig. 3. Consultations are not evenly divided among species (A), consulting agencies (B), or the types of work undergoing consultation (C). These high-level overviews provide a glimpse into the breadth of section 7. The top 10 species are dominated by wideranging species in the eastern United States and a small number of narrow-range species that coincide with areas of heavy development. The US Army Corps of Engineers, which administers section 404 of the Clean Water Act, consults far more than any other single agency. Development and transportation projects, which occur nationwide, account for over 50% of all consultations.

none resulted in destruction/adverse modification of critical habitat and only one remaining consultation resulted in jeopardy. That project, however, was still allowed to proceed by adopting RPAs to minimize and partially offset its effects. These results stand in stark contrast to every broad analysis of section 7 completed to date (Table 2). From 1979 to 1981, FWS completed 8,817 informal and 1,945 formal consultations, finding jeopardy for 173 projects (8.9% of formal consultations) (8). Of those 173 projects, 8 were cancelled or withdrawn, partly or entirely because of section 7 (9). The percentage of jeopardy findings increased to 17.5% during 1987 to 1991: among the 2,000 projects requiring formal consultation, 350 had jeopardy findings, of which 18 were stopped by section 7 and another 35 had the potential to ultimately be blocked (10). For comparison, if the consultation process had not changed since 1987 to 1991, we would expect nearly 1,200 consultations with jeopardy conclusions, and over 60 jeopardy conclusions that could stop a project, during 2008 to early 2015. Similarly, Owen’s analysis of over 4,000 fish-related biological opinions from both Services found many more jeopardy and destruction/adverse modification conclusions ($n = 78$ for FWS) from 2005 to 2009 than we found from 2008 to 2015. If the consultation process had not changed since 2005 to 2008, we would expect ~490 jeopardy opinions during 2008 to early 2015. Note that our data do not address potential projects that were never proposed or were withdrawn because FWS had proposed a jeopardy finding (15).

There are at least three likely reasons for the observed change in jeopardy or adverse modification outcomes. First, and perhaps the one envisioned by the drafters of the Act, can be characterized as policy learning (e.g., ref. 16): that federal agencies have now learned to plan and propose projects that minimize harm to listed species. Some agencies are proposing projects with reduced impacts because they are coordinating more closely with FWS to shape the projects well before consultations begin. A second and undesirable reason for the drop in jeopardy findings is that FWS—in the face of persistent budget cuts, increasing workload, and mounting political pressure to minimize the economic impacts of endangered species conservation—is approving more projects that should have been altered to comply with the conservation standards under the Act

(15). One method of achieving this outcome is by reinterpreting the jeopardy and destruction/adverse modification prohibitions such that they are more difficult to trigger. The definitions of both phrases are ambiguous enough to enable this gradual reinterpretation without a rulemaking or official change in agency policy. This second reason is a policy failure arising from insufficient resources and sociopolitical support for FWS (17). A third explanation is that federal agencies are now more inclined to continue negotiating the scope of their proposed projects in response to FWS issuing a draft biological opinion with a jeopardy or destruction/adverse modification conclusion (18). If negotiations are successful, the final biological opinion will have neither of those conclusions. We understand that all three scenarios are likely at play, but we do not know their prevalence.

Although the number of jeopardy conclusions is far lower than the numbers found in previous studies, it is unclear whether listed species are receiving less protection as a result. One reason is that the rate of formal consultation from 2008 to 2015 (7.7%) is considerably higher than the 2.8% observed by Barry et al. from 1987 to 1991 (10) but considerably lower than the 22.1% from 1979 to 1981, when there were far fewer consultations and formal consultation procedures were not yet clarified. Most of the >6,000 formal consultations in our dataset likely require permittees to apply RPAs, which are minor project modifications intended to minimize harm from the project (19) and are not required for projects that end with informal consultation. An example is avoiding construction during a listed bird’s nesting season. Between the conservation benefits of RPAs and the likelihood that some federal agencies are now proposing projects with fewer harmful effects, certain listed species may be receiving as much protections as they did in the past because of the higher percentage of formal consultations. Other species, however, will likely continue to decline in this scenario because RPAs and other conservation measures are generally not designed to fully offset the harmful effects of projects and implementation of RPAs is rarely monitored. The cumulative effect of hundreds of these small projects is reduced populations or habitat, an outcome that some people refer to as “death by a thousand cuts” (20). Exploring the effects of the over 88,000 consultations on species recovery is essential to understanding the effectiveness of the Act.

Improving the efficiency of section 7 consultations is a goal that would benefit the Services and the regulated community. We found that although the median duration of formal consultations is approximately one-half the maximum allowed by statute, a substantial proportion (20%) of formal consultations take longer than the 135 d allowed (absent an extension). One possibility for improving the speed of consultations is for the Services to find ways to expedite analyses of the effects of an action on listed species. To that end, FWS is currently creating the Information for Planning and Conservation (IPaC) system, which is expected to dramatically streamline informal consultations and introduce both efficiencies and needed standards for formal consultations (21). However, there are limits to how much the duration of consultations can be shortened, particularly for complex activities. Consultations often require months or years to complete because of inadequate data on species, which may suspend FWS's analysis until better data are collected and provided. Delays may also arise because federal agencies provide incomplete information about their proposed projects.

Our analyses show that the regulated community has two particular opportunities to contribute significantly to both conservation of listed species and to improved consultation efficiency. The variable with the largest mean square was whether consultations were formal, with formal consultations adding an estimated 43.8 d to the expected consultation duration. This result indicates that the most direct way to reduce consultation duration is for action agencies to plan and propose projects that are not likely to adversely affect listed species and, hence, do not require formal consultation. That is, species benefit by not being adversely affected by federal actions, and the regulated community benefits by faster (informal) consultations. As noted above, one possible explanation for the lack of jeopardy or destruction/adverse modification conclusions is that agencies have learned to modify actions before or during section 7 consultation to avoid such conclusions. If FWS increases the use of informal consultations to enhance efficiency, it would also need to improve compliance monitoring and enforcement to ensure that permittees actually implement required conservation measures.

The data also show the efficiencies introduced through consultations on federal agency programs that authorize future actions under the program (e.g., a Bureau of Land Management program to begin developing solar energy projects in six western states). Although these initial, program-level consultations take slightly longer than standard consultations, subsequent formal consultations on the individual activities tied to the program take less than half the time of standard formal consultations (e.g., consultations on the individual solar energy projects). In theory, wider adoption of programmatic consultations would allow better analysis of the overall effects on listed species than if those actions were each approved separately through standard consultations. In practice, however, federal agencies need to improve how they assess the cumulative effects of individual projects (22). If they succeed at this, individual projects could be approved more quickly without undermining conservation.

Although the TAILS data and our analyses can address certain questions about section 7 consultations, these data cannot address the broader conservation question: Has consultation improved the conservation of listed species? There are at least two components to this question. First is the question of whether species are improving, stable, or declining (23) and then determining

what proportion of the trends are attributable to consultation. Key to understanding the mechanism is determining whether the analyses underlying consultations are robust enough to afford protections as intended in the Act. Our analysis of consultation duration reflects what FWS reports in its annual budget justification: the majority of formal consultations are completed on time (FWS 2015). In contrast, NMFS reported that less than 30% of its consultations in 2014 were completed on time (24). A recent analysis that included comparisons of consultations found that NMFS used better science than FWS (25), which may explain the difference in consultation duration. Although addressing the cause of this difference is beyond the scope of the present paper, we expect that more detailed and thorough consultations require more time to complete but will improve conservation outcomes in the long run.

The second question is perhaps the most important for conservation and yet the least understood: Are federal actions improving—or at least not impairing—the status of listed species? We currently have limited information on whether agencies are consulting with the Services to the full extent required by the Act. By extension, we do not know the extent to which state and local governments or private parties have pursued permits or funding from federal agencies that should have triggered consultation. We also do not know whether biological opinions and other consultation documents accurately describe the location and scope of projects as completed. Furthermore, we do not know whether permittees actually comply with the conservation requirements from biological opinions and assessments. NMFS has enabled the public to more easily answer some of these questions by posting the results of all their consultations online on the Public Consultation Tracking System website (<https://pcts.nmfs.noaa.gov>). What neither of the Services have made readily accessible, however, are the monitoring reports required by many biological opinions. Without these documents, it is often impossible to know whether RPMs and other conservation commitments have been performed, much less if they are effective for species (15). Although these important questions cannot be answered with the TAILS data, determining the answers is crucial to understanding the effectiveness of the Act. The significant drop in the number of jeopardy and destruction/adverse modification findings makes the answers especially important to evaluating whether consulted-on projects are impairing the conservation of listed species.

Actual data and their analysis are essential to understanding how laws and policies are implemented, and that understanding is core to making informed decisions that improve outcomes and efficiency. The framers of the Act recognized the central importance of using the best available data and science for conserving imperiled species. Using the best available data and very simple statistics, we have shown that FWS rarely finds jeopardy or destruction/adverse modification and that the duration of most formal consultations is far shorter than the maximum allowed by law. Not one project has been stopped or significantly altered as a result of FWS reaching either of these findings. Although our analyses raise a host of questions—e.g., whether consultation is improving conservation outcomes for listed species—our findings should lay to rest some of the common misconceptions about the law. With those misconceptions aside, effort can focus on improving both the conservation

Table 2. Rate at which the US Fish and Wildlife Service calls jeopardy has varied over the past three decades and decreased substantially since 2008

	US House of Representatives 1982 Report	Barry et al. (10)	Owen (11)	Present study
Time frame	1979 to 1981	1987 to 1991	2005 to 2009*	2008 to 2015
Informal consultation	8,817	71,560	NA	81,461
Formal consultation	1,945	2,000	1,085	6,829
Jeopardy	173 (8.9%)	350 (17.5%)	78 (7.2%)	2 (0.03%)

*Nos. include only FWS fish-related consultations.

effectiveness and implementation efficiency of the Act to recover imperiled species.

Methods and Materials

We acquired a copy of the data for all formal and informal consultations as recorded in the TAILS database by FWS biologists since 2008, from FWS in July 2014, and a data update in mid-May 2015. The variables and an explanation of each are provided in *SI Appendix*. After the update, the dataset consisted of over 2 million rows of data, with each species evaluated in each consultation afforded a single row because conclusions are made on a per-species basis rather than per-consultation basis.

We performed extensive data checks and corrected errors in our copy of TAILS: errors are expected when >1,300 people working over 7 y are entering data. We corrected apparent date errors for the start and end of consultation, most of which were simple typos; homogenized the names of action agencies; corrected work categories for which duplicates occurred because of simple typos; and set the Boolean “formal consultation” field to “true” if the conclusions for any species in a consultation could only be reached through formal consultation (e.g., if a jeopardy determination had been recorded). Because FWS uses different species names and style conventions between different databases (e.g., TAILS vs. annual expenditure reports to Congress), we homogenized all names against the most recent expenditure report (2013) names and style convention [i.e., common group, common specific (*Genus species* [var/sp])]] to improve interoperability. Last, because there are effectively only a small number of possible conclusions (e.g., not likely to adversely affect vs. likely to adversely affect, no jeopardy, no adverse modification) but a variety of ways the conclusions were recorded in TAILS, we standardize all conclusions following *Table S1*.

During the data check phase, we identified 198 consultations that were recorded in TAILS as formal consultations but lacked lists of species evaluated during consultation, or for which the TAILS record included either jeopardy or destruction/adverse modification conclusions. To ensure the species and conclusions were correct, we requested biological opinions or other original consultation documents from FWS through a Freedom of Information Act request. We reviewed all responses and updated the data as necessary. During the updating, we identified another four consultations with questionable conclusions and used phone calls and emails to FWS biologists to obtain the correct data. Although such a large dataset likely contains other minor errors that we were unable to detect, we assume here that those errors are unbiased and equally distributed above and below the median and mean estimates.

To facilitate analysis and data sharing, we created several additional variables from the TAILS data. Consultation duration (in days) was calculated as (i) conclusion date minus start date for informal consultations and (ii) conclusion date minus start of formal consultation date for formal consultations. The clock for meeting the regulatory deadline of 135 d for formal consultation starts when the

action agency requests formal consultation. The duration calculation, however, may be an overestimate because the clock stops if FWS requires the action agency to provide more information. To protect the identity of FWS biologists performing the consultations while still allowing analysis of individual-level effects on consultation duration and other factors, we used the Message Digest 5 (MD5) algorithm in the digest package for R 3.1.2 (26) to hash the names. Last, to reduce the size of the database and improve the efficiency of the web applications (see below), we collapsed the TAILS data from species x consultation per row to a single row per consultation with lists of species and conclusions embedded in each row.

We calculated median consultation durations and approximate 95% CIs of the median after removing missing data. Standard analysis of variance was used to test for differences in means among categories. To evaluate the factors most likely to influence consultation duration, we removed 2,468 consultations (2.8%) with duration above the 98th percentile of all durations; these extreme values are strongly influenced by factors other than those recorded in TAILS, and their removal dramatically improved the fit of the models (from $R^2 \approx 0.17$ to $R^2 \approx 0.34$). We then used a linear model, with the functions `lm` and `aov` in R, to estimate the effects of six variables (identity of the lead biologist, whether the consultation was formal or not, the fiscal year of the consultation, the number of species evaluated, the complexity of the consultation, and the type of action being consulted on) on consultation duration. The distribution of residuals was checked to ensure the normality assumption was met.

A primary goal of this work is to help the public understand how consultations are implemented. We used the Shiny framework for R (shiny.rstudio.com) to create an interactive web application for different audiences. The code for the application and used in the analyses described above is available at GitHub (https://github.com/Defenders-ESC/section7_explorer) and is licensed under the GNU Public License version 2. The application itself is licensed under a Creative Commons Attribution/Share-Alike license so that figures, maps, and other details can be used (with attribution) by anyone who is interested. Because the TAILS data are created by US Government employees, the data are in the public domain and can be downloaded from within the application. We will be updating the data underlying the application on a quarterly basis.

ACKNOWLEDGMENTS. We thank G. Frazer and K. Paul for providing access to the TAILS database. We also thank A. Pericak and M. Evansen for assisting with the review of biological opinions and related documents acquired from FWS through Freedom of Information Act requests, and J. Rappaport Clark, D. Barry, N. Gloman, and M. Senatore for reviewing drafts of the manuscript and providing feedback. Two anonymous reviewers and the editor provided constructive feedback that improved the paper. This work was funded by Shared Earth Foundation and Woodtiger Fund, neither of which played a role in data collection, analysis, or interpretation.

- Chang HF, Sigman H (2014) An empirical analysis of cost recovery in superfund cases: Implications for brownfields and joint and several liability. *J Empir Leg Stud* 11(3):477–504.
- Mercer M, Palmiter AR, Taha AE (2010) Worthless warnings? Testing the Effectiveness of Disclaimers in Mutual Fund Advertisements. *J Empir Leg Stud* 7(3):429–459.
- Costanzo M, Shaked-Schroer N, Vinson K (2010) Juror beliefs about police interrogations, false confessions, and expert testimony. *J Empir Leg Stud* 7(2):231–247.
- Sugg IC (1993) Caught in the Act: Evaluating the Endangered Species Act, its effects on man and prospects for reform. *Cumb L Rev* 24(1):1–78.
- Thornberry M (2015) H.R.1735 - 114th Congress (2015-2016): National Defense Authorization Act for Fiscal Year 2016. Available at <https://www.congress.gov/bill/114th-congress/house-bill/1735>. Accessed August 17, 2015.
- Rohlf DJ (2001) Jeopardy under the Endangered Species Act: Playing a game protected species can't win. *Washburn LJ* 41(1):114.
- Government Accountability Office (2009) Endangered Species Act: The U.S. Fish and Wildlife Service has incomplete information about effects on listed species from section 7 consultations. GAO Report to Congressional Requesters GAO-09-550 (US Government Accountability Office, Washington, DC), pp. 1–34.
- US House of Representatives (1982) H.R. Report 97-567, Part 1. House of Representatives, Committee on Merchant Marine and Fisheries, Endangered Species Act Amendments (US Government Printing Office, Washington, DC).
- Parenteau P (1982) *Testimony of P. A. Parenteau, Vice President for Conservation, National Wildlife Foundation. Endangered Species Act Hearings Before the Subcommittee on Fisheries and Wildlife Conservation and the Environment, of the Committee on Merchant Marine and Fisheries. 22 February 1982 and 08 March 1982* (US House of Representatives, Washington, DC).
- Barry D, Harroun L, Halvorson C (1992) For conserving listed species, talk is cheaper than we think: The consultation process under the Endangered Species Act. Available at www.nativefishlab.net/library/textpdf/15635.pdf. Accessed August 17, 2015.
- Owen D (2012) Critical habitat and the challenge of regulating small harms. *Fla L Rev* 64: 141–199.
- Bean MJ, Rowland (1997) *The Evolution of National Wildlife Law* (Praeger, Westport, CT).
- Dwyer LE, Murphy DD, Ehrlich PR (1995) Property rights case law and the challenge to the Endangered Species Act. *Conserv Biol* 9(4):725–741.
- Simmons RT (1999) The Endangered Species Act. *Independent Review* 3(3): 309–326.
- Schwartz MW (2008) The performance of the endangered species act. *Annu Rev Ecol Evol Syst* 39:279–299.
- Sanderson I (2002) Evaluation, policy learning and evidence-based policy making. *Public Adm* 80(1):1–22.
- Head BW (2008) Wicked problems in public policy. *Public Policy* 3(2):101–118.
- U.S. House of Representatives (2003) *Endangered Species Act: Review of the Consultation Process Required by Section 7* (US Government Printing Office, Washington, DC).
- US Fish and Wildlife Service; National Marine Fisheries Service (1998) *Consultation Handbook: Procedures for Consultation and Conference Activities Under Section 7 of the Endangered Species Act* (US Fish and Wildlife Service and National Marine Fisheries Service, Washington, DC), Final.
- US Fish and Wildlife Service (2012) Endangered and threatened wildlife and plants; Revised critical habitat for the northern spotted owl; Proposed rule. *Fed Regist* 77(46): 14061–14165.
- US Fish and Wildlife Service (2015) US Department of the Interior Budget Justifications for Fiscal Year 2016: Fish and Wildlife Service. Available at www.fws.gov/budget/2015/FY2016_FWS_Greenbook.pdf. Accessed August 17, 2015.
- Duggan P (2011) Incidental extinction: How the Endangered Species Act's incidental take permits fail to account for population loss. *Environ Law Report* 7. Available at elr.info/news-analysis/41/10628/incidental-extinction-how-endangered-species-acts-incidental-take-permits-fai. Accessed September 30, 2015.
- Male TD, Bean MJ (2005) Measuring progress in US endangered species conservation. *Ecol Lett* 8(9):986–992.
- NOAA (2015) US Department of Commerce Budget Estimates: National Oceanic and Atmospheric Administration, Fiscal Year 2016. Available at www.corporateservices.noaa.gov/~nbo/fy16_bluebook/NOAA_FY16_CJ_508compliant_v2.pdf. Accessed August 17, 2015.
- Lowell NC (2015) Evaluating agency use of “best available science” under the Endangered Species Act. Master's thesis (University of Washington, Seattle).
- R Core Team (2014) *R: A Language and Environment for Statistical Computing* (R Foundation for Statistical Computing, Vienna). Available at www.R-project.org.