GRASS ROOT BUREAUCRATS: HOW PREDICTION MARKETS CAN INCENTIVIZE CITIZENS TO FILL ESA DATA GAPS

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INTRODUCTION

Prediction markets,[1] which allow participants to place bets on the probability of a particular event, have been used with great success in the election context. Virtually ubiquitous during the 2008 election, prediction markets were used to forecast the chances of a particular candidate winning the election, and were often used by Internet pundits to keep "score" of the polls throughout the run-up to November 4th.[2] Though the markets do not facilitate a formal, top-down style of information collection, the final election predictions still turned out to be quite accurate.[3]

Thus, prediction markets are clearly a valuable tool in the American electoral context. But do prediction markets have value

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1. I will use the term "prediction market" throughout this Note, but other scholars have referred to the same institutions as "information markets," "decision markets," or "ideas future markets." Tom W. Bell, *Prediction Markets for Promoting the Progress of Science and the Useful Arts*, 14 GEO. MASON L. REV. 37, 39 (2006).

2. *See, e.g.*, *Barack Obama Beating Hillary Clinton In Intrade Prediction Market*, THE HUFFINGTON POST, Feb. 7, 2008, http://www.huffingtonpost.com/2008/02/07/barack-obama-beating-hill_n_85489.html; Paul Krugman, The Conscience of a Liberal, http://krugman.blogs.nytimes.com/2008/09/10/even-odds/ (Sept. 10, 2008, 15:50 EST); Posting of eyesonobama to Daily Kos, http://www.dailykos.com/story/2008/10/28/174032/13/743/645054 (Oct. 28, 2008, 14:50 PST).

3. Intrade, the most popular prediction site for political wagering, predicted the electoral outcome of the United States presidential election almost exactly. Its only mishaps were Indiana and Missouri, although the latter was forecasted as a virtual toss-up. *Compare* Intrade, US Election 2008 Historical Data, http://www.intrade.com/jsp/intrade/intradeTV/ (last visited Apr. 9, 2010) (click on the graph below to see how Intrade forecasted the electoral outcome of each state over time; blue states signify an Obama victory and red states signify a McCain victory), *with* New York Times, Election Results 2008, http://elections.nytimes.com/2008/results/president/map.html (last visited Mar. 29, 2009).

in other fields? For many legal scholars, the answer is a resounding "yes."[4] For example, noted scholar Cass Sunstein has recently described prediction markets as "among the most intriguing institutional innovations of the last quarter-century."[5] Through the use of prediction markets, the quality of group deliberation can be made more objective because traders in these markets have a direct financial incentive to forecast the correct outcomes of uncertain events.[6] Furthermore, prediction markets are less subject to the cognitive errors and social pressures that normally affect decisions made by groups.[7] To that end, scholars have proposed that prediction markets can be designed to enhance agency decision-making,[8] corporate governance,[9] and the furtherance of scientific knowledge.[10]

Finally, prediction markets have the potential to combat what economist Friedrich A. von Hayek termed the knowledge problem—essentially, the idea that no central planner can ever gather enough relevant information to allocate resources efficiently.[11] This is because prediction market prices "aggregate[ ] both the information and the tastes of numerous people, producing judgments that incorporate more material than could possibly be assembled by any central planner, even one who insists on deliberation with and among experts."[12]

This Note will focus on the application of prediction markets to improve the functionality and efficiency of the Endangered Species Act (ESA).[13] One of the major problems hindering the effectiveness of the ESA is the prevalence of rampant data gaps, which prediction markets can help to fill. Though some environmental activists find market-based solutions to be anathema to their

4. *See, e.g.*, Michael Abramowicz & M. Todd Henderson, *Prediction Markets for Corporate Governance*, 82 NOTRE DAME L. REV. 1343 (2007); Bell, *supra* note 1; Miriam A. Cherry & Robert L. Rogers, *Prediction Markets and the First Amendment*, 2008 U. ILL. L. REV. 833 (2008); Cass R. Sunstein, *Group Judgments: Statistical Means, Deliberation, and Information Markets*, 80 N.Y.U. L. REV. 962 (2005).

5. Sunstein, *supra* note 4, at 962.

6. *See infra* note 31 and accompanying text.

7. *See infra* notes 31–36 and accompanying text.

8. *See* Michael Abramowicz, *Information Markets, Administrative Decisionmaking, and Predictive Cost-Benefit Analysis*, 71 U. CHI. L. REV. 933 (2004).

9. *See* Abramowicz & Henderson, *supra* note 4.

10. *See* Bell, *supra* note 1.

11. The "knowledge problem" refers to the fact that information needed to rationally allocate economic resources is so inherently decentralized that it can never be aggregated by a single planner. *See generally* F. A. Hayek, *The Use of Knowledge in Society*, 35 AM. ECON. REV. 519 (1945).

12. Sunstein, *supra* note 4, at 1023.

13. 16 U.S.C. §§ 1531–1544 (2006).

cause,[14] this Note argues that the ESA can act as a proving ground for prediction markets because of the localized nature of environmental problems. Moreover, this Note will offer specific suggestions about how a prediction market can be operationalized to address the particular information gaps that most need to be filled in order to effect optimal environmental policy, focusing explicitly on obtaining information from a broad segment of the population.

To demonstrate through a simplified example, the United States Fish and Wildlife Service (FWS) of the Department of the Interior might issue securities that pay out $10 upon the extinction of an endangered species residing in Montana within ten years. Participants would then buy and sell the securities, depending on their own assessment of the species' viability. Ultimately, the price would reach an equilibrium point dependant on the relevant information supplied by individual bettors in the form of securities bought and sold. In turn, this price would provide valuable information to the FWS. If the security price were to reach equilibrium at $3, for example, the price would indicate a thirty percent chance of extinction, and the FWS could adjust policy as appropriate. Even more importantly, prediction-market participants would be required to post all information relied upon to make their bets to a public forum for use by other participants and the FWS. This information, which might, for example, detail the location of species populations, would enable the FWS to further tailor policy.

Although the prediction market would be open to the public,[15] it would mostly attract participants with some form of inside knowledge concerning the species' health. These participants might range from Montana residents who have noticed a dwindling number of the species on their properties, to local developers who expect an increase in habitat-destroying commercial construction, to University of Montana biologists who think that this species' unique behavioral patterns make FWS models of extinction inaccurate. Moreover, dedicated trading firms may send representatives to Montana to interview residents about relevant information, thereby incorporating local knowledge into the security price indirectly.

14. *See, e.g.*, David Ehrenfeld, *Why Put a Value on Biodiversity?*, *in* BIODIVERSITY 212, 213 (E.O. Wilson ed., 1988) ("[B]y assigning value to diversity we merely legitimize the process that is wiping it out . . . ."); R. EDWARD GRUMBINE, GHOST BEARS 62 (1992) (arguing that economic models are inapplicable to environmental problems because "[h]umans cannot . . . impose limited notions of order on a living world that, by its very nature, will not be pinned down").

15. FWS employees would be excepted from trading on the markets.

If prediction markets are successfully implemented in the endangered species context, they will not only bring about more informed environmental policy, but provide a template as to how this tool can be used to engage citizens in a variety of contexts. If the full promise of prediction markets is ever realized, they may succeed in transforming agencies into "bottom-up" enterprises.[16] For example, many ESA decisions, although formally effectuated at the federal level, could be largely influenced by the knowledge of the local citizenry[17]—knowledge that is accumulated and represented by the bets placed on the prediction exchange.

Part I of this Note examines how prediction markets operate, their successes thus far, and the theoretical advantages they present as compared to other forms of information collection and analysis. Part II first offers a brief overview of the ESA and then explains why the Act is rife with information gaps that can potentially be filled through the use of prediction markets. At this point, the analysis will branch into separate discussions concerning two categories of data needed to successfully implement the ESA: scientific estimates concerning the numbers and habitats of species, and economic predictions of the consequences of inhibitive regulation. Part III describes how prediction markets can be structured to fill these information gaps and includes analysis on the different metrics that participants will attempt to predict. Part IV offers case studies on two types of agency action authorized by the ESA that have proven particularly problematic—species listing and critical habitat desig-

16. "Bottom-up" is a catch-all term to describe agencies that are more engaged with the private sector (either citizens, citizens' groups, or businesses) in order to arrive at more tailored and efficient regulations for their regulated constituents. Scholars employ various terminologies to describe the movement towards increased collaboration between agency and citizenry. Professor Stewart describes it as the rise of "government-stakeholder network structures," *see* Richard B. Stewart, *Administrative Law in the Twenty-First Century*, 78 N.Y.U. L. REV. 437, 448–50 (2003), while Professor Lobel speaks of agencies shifting from a regulatory to a governance paradigm, *see* Orly Lobel, *The Renew Deal: The Fall of Regulation and the Rise of Governance in Contemporary Legal Thought*, 89 MINN. L. REV. 342, 343–44 (2004). Professors Dorf and Sabel coined the term "democratic experimentalism" to describe an administrative framework in which "power is decentralized to enable citizens and other actors to utilize their local knowledge to fit solutions to their individual circumstances." Michael C. Dorf & Charles F. Sabel, *A Constitution of Democratic Experimentalism*, 98 COLUM. L. REV. 267, 267 (1998).

17. This Note advocates a variation from the typical devolutionist paradigm, in which local policy is determined by the local citizens' values or preferences. Such a paradigm would likely bring about regulatory repeals because endangered species regulations designed to benefit the whole nation often disproportionately hinder local economic interests. Under my model, ESA decisions would only be influenced by the technocratic knowledge of the local citizenry.

nation—and explores how prediction markets can rationalize the implementation of these policies. Part V will respond to potential objections to a prediction-markets model. Finally, Part VI will conclude.

I.
HOW PREDICTION MARKETS OPERATE

Prediction markets are similar to traditional equity markets, such as the New York Stock Exchange or NASDAQ, in the sense that prediction market participants—the general public—can enter online exchanges and buy and sell uniform assets. However, unlike equity markets, the relevant assets are not tied to an ownership stake in a company; instead, the asset payouts depend upon the occurrence of a particular event or condition.[18] For example, on Intrade, a popular online prediction market,[19] bettors can purchase contracts that pay out if Mitt Romney becomes the 2012 Republican presidential nominee,[20] if Chad Ochocinco wins Dancing with the Stars,[21] or if the United States or Israel performs an overt air strike against Iran before December of 2010.[22]

Valuable information can be inferred from the examination of market prices on Intrade and similar sites. For example, a contract that pays $10 if Tim Geithner departs as Treasury Secretary sold for $3 on January 29, 2010, suggesting that traders assign the Secretary a thirty percent chance of leaving his post.[23] If a majority of traders

18. *See* Abramowicz, *supra* note 8, at 934; Robert W. Hahn & Paul C. Tetlock, *Using Information Markets to Improve Public Decision Making*, 29 HARV. J.L. & PUB. POL'Y 213, 219 (2005).

19. Intrade is one of the most popular online prediction sites, but others include Betfair, http://www.betfair.com (last visited Mar. 10, 2010); Iowa Electronic Markets, http://www.biz.uiowa.edu/iem (last visited Mar. 10, 2010); Economic Derivatives, http://www.economicderivatives.com (last visited Mar. 10, 2010); and the Hollywood Stock Exchange, http://www.hsx.com (last visited Mar. 10, 2010).

20. Intrade, 2012 Republican Presidential Nominee, http://www.intrade.com/jsp/intrade/common/c_cd.jsp?conDetailID=652757&z=1269981701840 (last visited Mar. 31, 2010).

21. Intrade, Winner of Dancing with the Stars, http://www.intrade.com/jsp/intrade/common/c_cd.jsp?conDetailID=716907&z=1269982123161 (last visited Mar. 31, 2010).

22. Intrade, US/Israeli Overt Air Strike Against Iran, http://www.intrade.com/jsp/intrade/common/c_cd.jsp?conDetailID=667576&z=1269981895329 (last visited Mar. 31, 2010).

23. *See* Justin Wolfers & Eric Zitzewitz, *Interpreting Prediction Market Prices as Probabilities* (April 2006) (unpublished manuscript), *available at* http://www.nber.org/papers/w12200.pdf (arguing that prediction market prices typically closely

subsequently think that the probability of Geithner's departure is less than thirty percent, they will sell contracts until the market enters equilibrium. As a result, the price will decrease to reflect the lowered probability of the Secretary retaining office.

Although online markets are primarily used for entertainment and simple speculation, they have proven extraordinarily accurate in a variety of contexts.[24] As a result, the private and public sectors have begun to experiment with the use of prediction markets for information. For instance, in 2003, the Department of Defense briefly experimented with a market mechanism to predict future terrorist attacks.[25] The project, known as the Policy Analysis Market, was eventually shut down due to negative public reaction.[26] Additionally, firms such as Hewlett-Packard (HP) and Eli Lilly have had success using internal markets—those comprised entirely of company insiders—to predict sales and drug development, respec-

follow average trader beliefs of the probability that an event will occur); Intrade, How Does it Work?, http://www.intrade.com/jsp/intrade/help/index.jsp?page=howitworks.html (last visited Mar. 31, 2010). To see how the calculation works, assume that the contract price of $2.52 represents the expected value (EV) of the contract payouts. Given that the contract will pay out nothing if Romney loses, but $10 if he wins, then Romney must have approximately a twenty-five percent chance of winning. EV = $2.52 = (chance of Romney losing) x 0 + (chance of Romney winning) x $10. Thus, the chance of Romney winning = $2.52/$10 = 25.2%.

24. *See* Joyce Berg et al., *Results from a Dozen Years of Election Futures Market Research*, *in* 1 HANDBOOK OF EXPERIMENTAL ECONOMICS RESULTS 742, 747–48 (Charles R. Plott & Vernon L. Smith eds., 2008) ("[O]ver the majority of the time this market ran, its predictions were dramatically more accurate and stable than polls."); Refet Gürkaynak & Justin Wolfers, *Macroeconomic Derivatives: An Initial Analysis of Market-Based Macro Forecasts, Uncertainty, and Risk*, *in* NBER INTERNATIONAL SEMINAR ON MACROECONOMICS 2005 11, 21 (Jeffrey A. Frankel & Christopher A. Pissarides eds., 2007) (concluding that prediction markets are better than experts at estimating economic statistics); John Ledyard et al., *An Experimental Test of Combinatorial Information Markets*, 69 J. OF ECON. BEHAV. & ORG. 182, 182 (2009) ("In every known head-to-head field comparison, information markets have been no less accurate than other social institutions."); Saul Levmore, *Simply Efficient Markets and the Role of Regulation: Lessons from the Iowa Electronic Markets and the Hollywood Stock Exchange*, 28 J. CORP. L. 589, 593 (2003) (describing a prediction market which uses play money that has proven so successful at predicting box office returns that "studios have begun relying on these estimates to structure the distribution of their films").

25. Carl Hulse, *Pentagon Prepares a Futures Market on Terror Attacks*, N.Y. TIMES, July 29, 2003, at A1.

26. Carl Hulse, *Swiftly, Plan for Terrorism Futures Market Slips Into Dustbin of Idea Without a Future*, N.Y. TIMES, July 30, 2003, at A10.

tively.[27] Indeed, an academic study analyzing HP's prediction markets found they were more successful than official forecasts in six out of eight attempts.[28]

Why have prediction markets proven so successful? At the most basic level, the answer lies in the attributes that prediction markets share with markets in general:

> Markets are generally the best available mechanism for gathering and aggregating dispersed information from private, self-interested economic agents. . . . [I]f the prices in information markets are poor predictors of the future, speculators have a direct economic incentive to get better information and trade on their superior information, moving prices toward the expected value of the contract payments.[29]

The market's information discovery function is difficult to approximate through other means. For example, the only means by which the FWS incentivizes information collection is through salaries—by paying staff experts to engage in certain tasks.[30] Yet, the fact that these tasks are paid for by fixed fee elucidates the superiority of prediction markets, which offer financial incentives commensurate with the amount of useful information the seeker can discover such that he can calibrate his effort with the quantity of

27. *See* Abramowicz & Henderson, *supra* note 4, at 1349–50. Abramowicz & Henderson also mention the use of prediction markets at Siemens, GE, and France Telecom. *See id.* at 1350.

28. *See* Kay-Yut Chen & Charles R. Plott, Information Aggregation Mechanisms: Concept, Design and Implementation for a Sales Forecasting Problem 13 (March 2002) (unpublished manuscript), *available at* http://www.hpl.hp.com/personal/Kay-Yut_Chen/paper/ms020408.pdf.

29. Hahn & Tetlock, *supra* note 18, at 221. Some might criticize this statement by arguing that markets are inherently prone to asset bubbles caused by inherent behavioral biases. *See, e.g.*, GEORGE A. AKERLOF & ROBERT J. SHILLER, ANIMAL SPIRITS: HOW HUMAN PSYCHOLOGY DRIVES THE ECONOMY, AND WHY IT MATTERS FOR GLOBAL CAPITALISM (2009). While not denying the truth of this claim in the context of other markets, I contend that it is not necessarily applicable to prediction markets. For example, Akerlof and Shiller argue that asset bubbles are caused in large part by rising overconfidence, *id.*, but this problem does not seem applicable to prediction markets, which are not subject to an inherent upward trend. Abramowicz & Henderson, *supra* note 4, at 1355. Furthermore, the cheap credit that has so often fueled past asset bubbles, *see generally* ROBERT J. SHILLER, IRRATIONAL EXUBERANCE (2D ED. 2005), would not necessarily drive prediction market prices upwards, although it may encourage higher trading volumes if traders bet with borrowed money.

30. *See* U.S. GOV'T. ACCOUNTABILITY OFFICE, ENDANGERED SPECIES: FISH AND WILDLIFE SERVICE GENERALLY FOCUSES RECOVERY FUNDING ON HIGH-PRIORITY SPECIES, BUT NEEDS TO PERIODICALLY ASSESS ITS FUNDING DECISIONS, GAO-05-211, at 4 (2005), *available at* http://www.gao.gov/new.items/d05211.pdf.

data he expects to uncover. Moreover, prediction markets can be utilized by anyone with useful information; the "expert" need not have a relationship with the FWS nor negotiate a contract with the agency. From this perspective, a prediction market can act as a contracting device that massively reduces the agency's search and transaction costs. The markets incentivize parties to provide labor for the agency and customize compensation according to the value that the "expert" provides, even though the researcher might only have a passing relationship with the FWS.

Even when all possible information is available to a decision maker, prediction markets have value in that they promote objective decision-making. This is because traders have a direct financial incentive to recognize and correct any cognitive defect in reasoning.[31] Principally, this economic motivation counters the heuristics and social dynamics that often systematically skew group decision-making.[32] This function is particularly helpful in the agency setting because of the omnipresence of bureaucratic pathologies such as interest group pressure and availability cascades.[33]

The objectivity of the market is further enhanced by the ability to canvass "the wisdom of crowds"—the tendency for group estimates, as measured by the average response, to outperform individual estimates.[34] Even if one trader errs in his estimate because of personal bias, this theory states that this effect will not be noticeable in the aggregate as long as a majority of traders are more likely to be right than wrong and the number of traders is sufficiently

31. Sunstein, *supra* note 4, at 1024–25.

32. First, by contrast, a deliberative group tends to amplify the cognitive errors of its individuals. These predictable cognitive defects include the representative heuristic, in which judgments of probability are influenced by assessments of resemblance; the availability heuristic, in which difficult questions of probability are answered based on whether answers immediately come to mind; and framing effects, in which answers are influenced by the wording of the question. *Id.* at 990–93. Second, groups often struggle to properly aggregate information within their possession because of the "common knowledge effect," through which information held by all group members has more influence on group judgments than information held by a minority. *Id.* at 994–99. Third, reputational cascades may cause group members to ignore what they know to be correct so they may maintain the good opinion of others. *Id.* at 1002–04. Finally, an effect known as group polarization results in group members articulating more extreme positions once deliberation begins. *Id.* at 1004–06.

33. *See* Abramowicz, *supra* note 8, at 966–71. An availability cascade is a "self-reinforcing process of collective belief formation by which an expressed perception triggers a chain reaction that gives the perception increasing plausibility through its rising availability in public discourse." Timur Kuran & Cass R. Sunstein, *Availability Cascades and Risk Regulation*, 51 STAN. L. REV. 683, 683 (1999).

34. *See generally* JAMES SUROWIECKI, THE WISDOM OF CROWDS (2004).

large.[35] "The wisdom of crowds" might partly explain why information markets have repeatedly been shown to best the predictions of fully informed experts.[36]

Prediction markets might also shine a light on the relatively opaque processes of agency decision-making. Market data provides interested parties with an instant snapshot of the scientific or economic consensus on the matter, which enables parties to cultivate informed assessments of the agency or legislature's priorities or machinations.[37] For instance, if the agency generally follows market consensus but suspiciously ignores the market's exhortation to regulate in a particular instance, the deviation might alert environmental advocates that interest group pressures or other non-policy considerations are at play.

Additionally, the markets might help uncover shifts in regulatory attitude. If a new administration displays consistent skepticism towards predictions that justify additional regulation, this can serve as evidence of a shift in executive priorities. Absent the mechanism of prediction markets, the administration could potentially disguise the shift by slanting their presentation of the relevant evidence, but prediction markets are not as easily manipulated because they depend on political outsiders making independent judgments to advance financial, rather than political, priorities.[38]

Use of prediction markets in government agencies, in particular, would engender a great amount of transparency. Ideally, all citizens in a democratic state would acquaint themselves with ex-

35. *See id.*; Sunstein, *supra* note 4, at 971–74.

36. *See* Hahn & Tetlock, *supra* note 18, at 222; *see also* sources cited *supra* note 24.

37. *See* Abramowicz, *supra* note 8, 969–71; Hahn & Tetlock, *supra* note 18, at 263–65.

38. One might contest that the type of transparency mentioned above can already be obtained by perusing unbiased empirical research. Strictly speaking, this is true, but it is difficult for most citizens to compile sufficient amounts of research without cumbersome efforts. In contrast, prediction markets compile thousands of bits of data into a single, easily interpretable value, which informs traders' bets. *Cf.* Bradley C. Karkkainen, *Information as Environmental Regulation: TRI and Performance Benchmarking, Precursor to a New Paradigm?*, 89 GEO. L.J. 257, 295 (discussing the value of standardized, and therefore easily comparable, information in promoting accountability). The prediction market offers the additional benefit of allowing inter-temporal comparisons. Hahn & Tetlock, *supra* note 18, at 263. Even if an agency adopts a consistent regulatory position throughout a political term, the markets might indicate that the position is increasingly extreme because it is more and more discordant with scientific or economic reality. By comparison, empirical studies can be compared across time, but any change in methodology would make even direct quantitative comparisons inexact.

pert opinion with regard to important policy matters. Prediction market prices, if made available online, could provide citizens with a quick summary of expert consensus. One possible salutary result is that if government action is consistent with the shown consensus, this may increase the chances of societal acceptance of the action's legitimacy, particularly amongst persons whose personal interests are harmed by the action.[39] Additionally, prediction markets could increase the incidence of civic action. For example, county residents incensed by the market's prediction of the imminent extinction of a beloved creature in the area may be motivated to organize and apply private pressure to the businesses at the root of the problem.[40]

In sum, prediction markets can theoretically supply the FWS with more accurate and objective information and a more transparent process for information production. The rest of this Note is devoted to a discussion of how these theoretical benefits would actually come about in practice.

II.
APPLYING PREDICTION MARKETS TO THE ESA

A. Introduction to the ESA

The ESA is primarily administered by the FWS.[41] The ESA's stated goal is "conservation," which requires the FWS not only to ensure the survival of species, but also to increase those species' numbers so that they can exist without the safeguards provided by the ESA.[42] One of the FWS' central responsibilities is the task of

39. *See* Abramowicz, *supra* note 8, at 970 ("Yet agencies will be better able to pursue policies in which the claimed justification would in fact be sufficiently persuasive, because information markets can reduce the informational asymmetry and thus help to reduce distrust.").

40. *See* Karkkainen, *supra* note 38, at 316–23 (describing how easily obtainable and objective information can encourage community monitoring by triggering awareness, leveling the field for negotiations and facilitating enforcement).

41. The National Marine Fisheries Service (NMFS) and the FWS share responsibility for implementation of the Act. Generally, the FWS manages land and freshwater species, while the NMFS cares for marine and "anadromous" species. But since the NMFS only has jurisdiction over sixty-eight species, I will refer exclusively to the FWS throughout this Note. NOAA Fisheries, Office of Protected Resources, Endangered Species Act (ESA), http://www.nmfs.noaa.gov/pr/laws/esa/ (last visited Mar. 22, 2010).

42. 16 U.S.C. §§ 1531(b), 1532(3) (2006). The FWS has arguably had success in fulfilling its first goal: one estimate claims the ESA has saved 227 species from extinction. J. Michael Scott et al., *By the Numbers*, *in* 1 THE ENDANGERED SPECIES ACT AT THIRTY: RENEWING THE CONSERVATION PROMISE 16, 31 (Dale D. Goble et al.

listing "endangered" species—those "in danger of extinction throughout all or a significant portion of its range."[43] The agency can also list a species as "threatened" if the species is likely to become endangered in the foreseeable future, but the consequences are similar to that of an "endangered" listing.[44] The Secretary of the Interior can list a species on his own accord, and citizens can also submit petitions to encourage a listing, to which the Secretary must respond within twelve months.[45] As of March 2010, the FWS has listed 1540 endangered species and 360 threatened species.[46]

A listing triggers a series of legal consequences. First, the FWS is required to designate the species' "critical habitat"[47] concurrent with the listing.[48] In doing so, the agency can consider the "economic impact" or "any other relevant impact" of the designation.[49] The only legal effect generated by a critical habitat designation is found in Section 7 of the ESA, which requires federal agencies to consult with the FWS to insure that "any action authorized, funded, or carried out by such agency . . . is not likely to jeopardize the continued existence of any endangered species or threatened spe-

eds., 2006). However, as of 2003, the ESA had led to the recovery of a mere thirteen species. *Id.* at 33.

43. § 1532(6).

44. § 1532(20). A "threatened" listing allows the Secretary statutory flexibility to craft narrow prohibitions on takings. § 1533(d). However, the FWS generally imposes the same Section 9 restraints that are applied to "endangered" species. Steven P. Quarles & Thomas R. Lundquist, *The Pronounced Presence and Insistent Issues of the ESA*, 16 NAT. RESOURCES & ENV'T. 59, 63 (2001).

45. § 1533(b)(3). Today, most listings come about through the latter process, particularly as a result of petitions submitted by environmental groups. *See* Katrina Miriam Wyman, *Rethinking the ESA to Reflect Human Dominion Over Nature*, 17 N.Y.U. ENVTL. L.J. 490, 496 (2008).

46. U.S. Fish & Wildlife Service, Summary of Listed Species: Listed Populations and Recovery Plans, http://ecos.fws.gov/tess_public/Boxscore.do (last visited Mar. 2, 2010).

47. This is defined as:

> (i) the specific areas within the geographical area occupied by the species . . . on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied . . . upon a determination by the Secretary that such areas are essential to the conservation of the species.

§ 1532(5)(A).

48. § 1533(a)(3)(A)(i).

49. § 1533(b)(2). Notably, this is the only instance where the Act permits consideration of such criteria. See, for example, § 1533(b)(1)(a), which makes no mention of "economic impact" and states that the "Secretary shall make [listing] determinations . . . solely on the basis of the best scientific and commercial data available."

cies or result in the destruction or adverse modification" of its critical habitat.[50] This requirement can be quite burdensome: it forced over 219,000 formal and informal consultations between 1998 and 2001 alone.[51]

In addition to restrictions on federal actions, a listing prohibits public and private actors from "tak[ing]" any endangered species.[52] "Take" is defined broadly through the statute and a regulation to include killing, harassing or harming the species directly, or through degradation of the species' habitat.[53] Until the 1980s this provision was rarely enforced,[54] but since then it has become one of the most controversial provisions of the Act,[55] as it has the greatest inhibitory effect on private citizens.[56] The Secretary is able to blunt this provision's force by issuing permits allowing a taking if it is "incidental to . . . the carrying out of an otherwise lawful activity," but the applicant must first submit a conservation plan that will "minimize and mitigate" the impact of the taking.[57] Furthermore, the process is extremely costly and time consuming: individual permits must be negotiated, then subjected to an environmental assessment, and finally published in the Federal Register for comment.[58]

B. Applying Prediction Markets to Scientific Data Gaps

Both listing decisions and critical habitat determinations require the compilation and review of voluminous amounts of data. The FWS is statutorily obligated to consider, among other factors,

50. § 1536(a)(2).

51. U.S. FISH & WILDLIFE SERVICE, CONSULTATION WITH FEDERAL AGENCIES: SECTION 7 OF THE ENDANGERED SPECIES ACT 2 (2002), http://library.fws.gov/Pubs9/consultations.pdf.

52. *See* § 1538(a)(1).

53. § 1532(19); 50 C.F.R. § 17.3 (2006); *see also* Babbitt v. Sweet Home Chapter of Cmtys. for a Great Oregon, 515 U.S. 687, 696–704 (1995) (affirming a broad reading of the statute encompassing indirect "takings").

54. Barton H. Thompson, Jr., *The Endangered Species Act: A Case Study in Takings & Incentives*, 49 STAN. L. REV. 305, 310 (1997).

55. *See* Jonathan H. Adler, *Money or Nothing: The Adverse Environmental Consequences of Uncompensated Land Use Controls*, 49 B.C. L. REV. 301, 347–51 (2008) (surveying the means by which private landowners offer political resistance to the ESA).

56. *See* Thompson, *supra* note 54, at 310 ("Section 9 gives the federal government immense and broad authority over private land use decisions in many regions of the nation.").

57. 16 U.S.C. § 1539(a) (2006).

58. *See* Thompson, *supra* note 54, at 317–18; Albert C. Lin, Note, *Participants' Experiences with Habitat Conservation Plans and Suggestions for Streamlining the Process*, 23 ECOLOGY L.Q. 369, 376–81 (1996) (describing the process of developing a Habitat Conservation Plan).

threats to an animal's habitat, the risk it faces from disease or predation, and the inadequacy of existing regulatory mechanisms when deciding whether a species is "endangered."[59] When designating a critical habitat, the FWS must determine the area occupied by the species "on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection."[60]

Luckily, the FWS has access to a wide network to aid in the gathering of this data. After receiving basic information about a given species' status in the listing petition, the FWS contacts federal, state, local, and tribal agencies; interested conservation or industry groups; and scientists or professional organizations possessing special knowledge about the species.[61] It also solicits several rounds of comments from the general public through notice-and-comment-rule-making[62] and utilizes formal peer-review procedures.[63] Finally, draft rules receive "considerable internal review" from officials at field, regional, and headquarters offices before being published.[64]

These procedures are elaborate, but not foolproof. The most obvious way in which prediction markets could improve current FWS procedures is by aiding the collection of demographic data. Since one of the primary goals of the ESA is minimizing the risk of extinction, the FWS must naturally obtain extinction risk estimates in order to prioritize species protection.[65] However, such estimates are obviously less accurate when the population size and location of the species are unknown.[66] If distinct populations of the species

59. § 1533(a)(1).

60. § 1532(5)(A).

61. U.S. GEN. ACCOUNTING OFFICE, ENDANGERED SPECIES: FISH AND WILDLIFE SERVICE USES BEST AVAILABLE SCIENCE TO MAKE LISTING DECISIONS, BUT ADDITIONAL GUIDANCE NEEDED FOR CRITICAL HABITAT DESIGNATIONS, GAO-03-803, AT 12 (2003), *available at* http://www.gao.gov/new.items/d03803.pdf.

62. *Id.*

63. *See infra* notes 93–97 and accompanying text.

64. U.S. GEN. ACCOUNTING OFFICE, *supra* note 61, at 12–13.

65. There are far more imperiled species than the number that can be protected under the ESA, thus necessitating the need for prioritization such that the neediest can be protected. *See infra* note 144 and accompanying text.

66. *See* Mary Ruckelshaus & Donna Darm, *Science and Implementation*, *in* 2 THE ENDANGERED SPECIES ACT AT THIRTY: CONSERVING BIODIVERSITY IN HUMAN-DOMINATED LANDSCAPES 104, 112 (J. Michael Scott et al. eds., 2006) ("Research is needed on how best to make population or species demographic parameter estimates from spotty census information."); Holly Doremus, *Listing Decisions Under the Endangered Species Act: Why Better Science Isn't Always Better Policy*, 75 WASH. U. L.Q.

live in separate locations, then researchers must also identify movements between populations and correlations of fate in the event of catastrophe.[67] Aside from prioritization, information on species range and habitat are crucial for enforcement of both Sections 7 and 9.[68]

1. Prediction Markets and the Creation of Private Incentives

Because endangered and threatened species have small populations, they are difficult to document with comprehensive detail.[69] Interestingly, the result of incomplete documentation is that FWS employees and private citizens occasionally make discoveries of entirely new populations.[70] Yet, the FWS possesses no mechanism to account for such discoveries, and valuable demographic information often slips by undetected.[71] The prediction market not only provides such a mechanism, but also actively encourages persons to make reasonable efforts to discover census data. The slim chance

1029, 1119 (1997) ("With data on the simple presence or absence of a species so difficult to collect, determining nesting success or evaluating population trends can be nearly impossible."); W. Parker Moore, *Back to the Drawing Board: A Proposal for Adopting a Listed Species Reporting System Under the Endangered Species Act*, 24 UCLA J. ENVTL. L. & POL'Y 105, 124 (2006) ("Without being able to pinpoint a species' range, population locations, and habitat with verifiable accuracy, the Services cannot afford that species the protections which Congress contemplated in the ESA.").

67. WILLIAM MORRIS ET AL., THE NATURE CONSERVATORY, A PRACTICAL HANDBOOK FOR POPULATION VIABILITY ANALYSIS 49–52 (1999), http://training.fws.gov/ec/resources/advanced_sec_7/june_2005/scientific_references/tnc_morris_etal_1999.pdf.

68. For example, to prove that a habitat modification constitutes a "taking," the FWS might have to show that the act "significantly impair[s] essential behavioral patterns." 50 C.F.R. § 17.3 (2006).

69. *See* Kristen Carden, *Bridging the Divide: The Role of Science in Species Conservation Law*, 30 HARV. ENVTL. L. REV. 165, 202–03 (2006) ("[I]n the species conservation context, there is never 'enough' science available when a decision needs to be made. . . . For a lesser known species. . . information on population status . . . is virtually nonexistent."); *see also* Doremus, *supra* note 66, at 1119; Moore, *supra* note 66, at 109–10.

70. Moore, *supra* note 66, at 110 (citing Interview with Martin Miller, Chief, United States Fish & Wildlife Service—Region 5, Division of Threatened and Endangered Species (Apr. 27, 2004) (noting that discovery of new information concerning listed species "happens pretty frequently" because the Services generally lack site-specific information for many species, especially during the first few years immediately following a species' listing)). Indeed, the watershed case *Tennessee Valley Authority v. Hill* came about because a University of Tennessee ichthyologist discovered a previously unknown species later identified as the snail darter. *See* 437 U.S. 153, 158 (1978).

71. Moore, *supra* note 66, at 110.

of finding a new population will not provide enough incentive for individuals to comb the countryside, but it may inspire a landowner to inspect his own property. Especially given that the majority of endangered species reside at least in part on private land,[72] such reasonable efforts may be enough to generate vastly improved census data.[73]

Indeed, one of the difficulties associated with current data collection practices is the reluctance of landowners to cooperate with the FWS for fear that a discovery of endangered populations will bring about Section 9 land use regulations. Private landowners are often reluctant to let FWS researchers on the property, much less voluntarily disclose demographic information.[74] Prediction markets would partially overcome these concerns by giving the landowner a direct financial incentive to make such disclosures: he could simply place a bet forecasting the survival of the species, and then expect the market to move in the direction of his bet upon disclosure of the previously unknown populations on his land.[75]

72. U.S. GEN. ACCOUNTING OFFICE, ENDANGERED SPECIES ACT: INFORMATION ON SPECIES PROTECTION ON NONFEDERAL LANDS, GAO/RCED-95-16, AT 4 (1994); *see also* Jodi Hilty & Adina M. Merenlender, *Studying Biodiversity on Private Lands*, 17 CONSERVATION BIOLOGY 132, 133 (2003) (estimating that some habitat for ninety-five percent of endangered species is on private property); David S. Wilcove & Joon Lee, *Using Economic and Regulatory Incentives to Restore Endangered Species: Lessons Learned from Three New Programs*, 18 CONSERVATION BIOLOGY 639, 640 (2004) (noting a recent estimate that at least one population of two-thirds of federally listed species reside on private land).

73. *Cf.* Adler, *supra* note 55, at 333 ("In some cases, a private landowner might be the only person who knows a listed species is on their land."); Christopher S. Elmendorf, *Ideas, Incentives, Gifts, and Governance: Toward Conservation Stewardship of Private Land, in Cultural and Psychological Perspective*, 2003 U. ILL. L. REV. 423, 432 ("Rural landowners may find it difficult to monitor their property, but they have it easier than the government.").

74. Adler, *supra* note 55, at 332–33; Doremus, *supra* note 66, at 1120. Moreover,

> [a] landowner's refusal to allow on-site surveys can effectively limit the listing agencies to reliance on historic occurrence records, remote sensing methods, and surveys of government-owned property. Given these obstacles, it may be virtually impossible in some cases to demonstrate that a species is approaching extinction before it is too late.

Id.

75. Note that the landowner has no incentive to kill these unknown populations after betting on their demise. If he were to do so, and then disclose the animals' deaths to the public, the market price associated with the animals would be unlikely to shift. This is because market participants would have previously thought that no animals were present on the landowner's land (since the population was unknown), and the disclosure of the animals' deaths would merely confirm this belief. If the population were known, then the landowner could

True, the financial incentive might not be commensurate with the costs of regulation in all instances, but if the landowner intends to keep the information hidden, he must contend with the possibility of neighbors making similar disclosures.[76] This leaves the landowner with a prisoner's dilemma of sorts: faced with the risk that a neighbor will disclose the population's existence, he will opt to make the disclosure himself so that he is at least likely to achieve some financial gain.[77]

Just as prediction markets can encourage citizens to inspect their properties for species sightings, they can similarly encourage them to look for habitat structures essential to endangered species' survival—information obviously relevant to the designation of critical habitat. Some observers believe that the information currently used to perform designations is sometimes inadequate, both because of the time constraints involved and the sheer difficulty of collecting habitat data.[78] As evidence of the latter point, consider FWS efforts to document vernal pool environments, which are small wetlands ranging from puddles to shallow lakes[79] and are a habitat to fifteen different endangered species.[80] Vernal pools are characterized by their ability to remain dormant, or completely dried up for years, such that the FWS "cannot quantify in any meaningful way what proportion of each critical habitat unit may be actually occupied" by vernal pools.[81] Although the FWS eventually did send staff to some of the pools to conduct in-person examinations,[82] it doubtless could have provided a more tailored critical

theoretically bet in favor of extinction, kill the animals, and make a profit. However, such illegal behavior would be difficult to cover up since the bet would be traceable to the landowner, and it might come too late to forestall regulation because the animals' presence would already be known to regulators.

76. Even if the species exists in only one tract, Professor Elmendorf points out that "neighbors can peer across fence lines, and neighbors pick up gossip like lint." Elmendorf, *supra* note 73, at 432.

77. Imagine that the regulation resulting from disclosure would cost the landowner $10,000, but she could earn $5,000 by placing a bet and then disclosing the information to the market. Although the disclosure would net her a loss of $5,000, she would effectively lose $10,000 if she failed to do so and a neighbor made the disclosure instead.

78. *See* U.S. GEN. ACCOUNTING OFFICE, *supra* note 61, at 19–20; *see also infra* notes 69–70 and accompanying text.

79. U.S. Environmental Protection Agency, Vernal Pools, http://www.epa.gov/owow/wetlands/types/vernal.html (last visited Mar. 25, 2010).

80. Home Builders Ass'n of N.C. v. U.S. Fish & Wildlife Serv., No. CIV. S-05-0629 WBS-GGH, 2006 WL 3190518, at *3 (E.D. Cal. Nov. 2, 2006).

81. *Id.* at *1, *14.

82. *Id.* at *19.

habitat designation if it received information contributions from residents in the area who had been able to observe the vernal pools over a number of years.

Habitat information is also important to species listing decisions because habitat destruction is often the key factor pushing the species into peril;[83] of course, large data gaps exist in this context as well.[84] For example, in *Western Watersheds Project v. Fish and Wildlife Service*, the court struck down the Service's listing decision in part because crucial information was missing for seventy-eight percent of the sage grouse's habitat.[85] The FWS was unable to identify whether certain oil and gas leases contained sage grouse protections, nor whether Best Management Practices designed by the Bureau of Land Management (BLM) were effective in improving sage grouse habitats on land managed by the Bureau.[86] However, both of these data gaps likely could have been filled by industry experts or BLM officials, simply by using the incentives provided by the prediction market: the chance to turn a profit by utilizing superior information.

2. Prediction Markets and Reliability

Prediction markets do not only increase the amount of information available to the FWS, but can also make that information more reliable. Most of the "scientific" data utilized by the FWS is infused with subjectivity. For instance, since the mechanisms of extinction are still poorly understood, the models used to develop extinction probabilities rely on simplifying assumptions, many of which have not been verified by field data.[87] Consequently, Holly Doremus characterizes such models as "hunches."[88] To make matters worse, the models often go unpublished, meaning they cannot be replicated.[89] And when census data is limited, biologists are forced to resort to rules of thumb or simply use habitat loss as a rough proxy for species decline.[90] The aggregative nature of the prediction market avoids the risk of idiosyncratic guessing—a threat to an agency that relies on the views of a single scientist, or a

83. *See, e.g.*, David S. Wilcove et al., *Quantifying Threats to Imperiled Species in the United States*, 48 BioScience 607, 607 (1998).

84. *See infra* note 172.

85. *See* 535 F. Supp. 2d 1173, 1187 (D. Idaho 2007).

86. *Id.*

87. Doremus, *supra* note 66, at 1119.

88. *Id.*

89. *Id.*

90. *Id.* at 1121.

few who are subject to an availability cascade.[91] The prediction market would also help to filter out individual biases, particularly the political opinions that materialize among scientists when dealing with an ideologically-charged matter such as species protection.[92]

Of course, the scientific community already possesses a method for filtering out biases and idiosyncrasies: peer review. Formally, the FWS is supposed to solicit the opinions of three specialists for "listing and recovery activities,"[93] which usually results in approval of the agency's policies.[94] However, these seemingly positive results are suspect because the agency implements an ad hoc model of peer review with no means of ensuring the objectivity of its reviewers.[95] Moreover, scientifically rigorous peer review demands time and resources that simply are not available to the agency,[96] and reviewers have little incentive to volunteer their time and effort.[97]

The lack of objective peer review not only undermines accuracy, but insures limited political transparency. Many decisions under the ESA are supposed to be made in accord with the "best scientific and commercial data available,"[98] but the line between politics and science is thin. If interest group pressure demands a

91. *See supra* note 33.

92. Keep in mind that the scientific norm of political neutrality has significantly eroded. *See* Doremus, *supra* note 66, at 1149. Note also that debates over land use regulation have proven extremely divisive, partly because of the divergent cultural attitudes of the combating participants. *See* Elmendorf, *supra* note 73, at 433–34.

93. Endangered and Threatened Wildlife and Plants: Notice of Interagency Cooperative Policy for Peer Review in Endangered Species Act Activities, 59 Fed. Reg. 34,270, 34,270 (July 1, 1994).

94. U.S. GEN. ACCOUNTING OFFICE, *supra* note 61, at 21–22 (stating that between fiscal years 1999 and 2002, peer reviewers disagreed with the FWS in only two instances).

95. *See id.* at 15–16; *see also* J.B. Ruhl, *The Battle Over Endangered Species Act Methodology*, 34 ENVTL. L. 555, 586 (2004).

96. *See* U.S. GEN. ACCOUNTING OFFICE, *supra* note 61, at 15–16 (noting that peer review normally must occur within an abbreviated time frame and that the FWS is often unable to find independent reviewers because of the "scarcity of experts on a particular species"); Ruhl, *supra* note 95, at 591 ("[S]ome species simply do not have the time that the Scientific Method demands.").

97. Holly Doremus, *The Purposes, Effects, and Future of the Endangered Species Act's Best Available Science Mandate*, 34 ENVTL. L. 397, 435 (2004); *see also* Anne Hecht & Mary Parkin, *Improving Peer Review of Listings and Recovery Plans under the Endangered Species Act*, 15 CONSERVATION BIOLOGY 1269, 1272 (2001) (suggesting that the Service should compensate peer reviewers).

98. 16 U.S.C. § 1533(b)(1)(A) (2006).

particular result and the decisive data is little more than a guess, pressure to reinterpret the "evidence" may be significant.[99] The fact that the "best scientific and commercial data available" is such a vague standard exacerbates the problem.[100] Furthermore, scientific uncertainty allows the agency to hide value choices within simplifying assumptions.[101] For instance, conservative assumptions may represent an application of the precautionary principle rather than skepticism towards field data.[102]

Given the reasons to suspect the efficacy of peer review as currently practiced,[103] the "market check" provided by prediction ex-

99. *See, e.g.*, U.S. GEN. ACCOUNTING OFFICE, *supra* note 61, at 20 ("[I]nterested parties representing a diverse set of interests raised concerns that Service officials at the Headquarters level are succumbing to political pressures to not list species despite support from regional and field scientists who believe evidence shows that listing is warranted."). An extreme example of such meddling occurred during the tenure of Julie MacDonald as Deputy Assistant Secretary for Fish and Wildlife and Parks. Ms. MacDonald and other officials repeatedly commanded scientists to alter their methodologies in order to arrive at different conclusions calling for less regulation, even when the alternate conclusions conflicted with the "best available science." *See* OFFICE OF THE INSPECTOR GEN. OF THE U.S. DEP'T OF THE INTERIOR, INVESTIGATIVE REPORT: THE ENDANGERED SPECIES ACT AND THE CONFLICT BETWEEN SCIENCE AND POLICY 1–2 (2008).

100. U.S. GEN. ACCOUNTING OFFICE, *supra* note 61, at 9; *see also* Memorandum from Earl E. Devaney, Inspector Gen. of the U.S. Dep't of the Interior, to Dirk Kempthorne, U.S. Sec'y of the Interior (Dec. 15, 2008) (contending that Ms. MacDonald's abuses were in part caused by the enormous discretion afforded to the FWS).

101. *See, e.g.*, Doremus, *supra* note 66, at 1087–88 (arguing that ESA listing decisions involve decisions of taxonomy and viability, which appear to be value-neutral and scientific, but the agencies have to look beyond scientific information).

102. The precautionary principle states that "[w]here there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." Ruhl, *supra* note 95, at 565 (quoting Rio Declaration on Environment and Development, UNCED, U.N. Doc. A/CONF.151/Rev. 1, 31 I.L.M. 874, 879 (1992)). The decision to employ the principle is a normative one. *Id.* at 569.

103. Notice-and-comment-rule-making and judicial review also serve as external checks on the FWS, but the efficacy of these institutions in promoting objectivity is limited. Courts grant the Service heavy deference when reviewing its decisions, only demanding a "rational connection" between the facts and the outcome. U.S. GEN. ACCOUNTING OFFICE, *supra* note 61, at 22. As a result, most litigation does not concern the Service's use of science, and instead turns on definitional or procedural issues. *Id.* Those who comment on proposed rules may provide substantive guidance, but no mechanism exists for ensuring its objectivity. In addition, given the Service's troubles with recruiting scientists in the peer review context, it is even less likely that the relevant experts would offer their services during the notice-and-comment period, when their advice is not specifically requested. *See* Doremus, *supra* note 97, at 435.

changes might be especially valuable. To be sure, prediction markets provide a different type of analysis: scientists seek to minimize false positives at the cost of false negatives when reviewing others' work,[104] which is not necessarily the case for "trader reviewers." Also, traders will not always engage in rigorous review; instead, they will only devote resources commensurate with the financial benefits that can be obtained by expected increases in accuracy. Despite these limitations, the market check remains a cheap substitute for peer review because of its provision of objectivity to an inherently subjective process.

Finally, the dynamism of prediction markets is perfectly suited to ecological research. The currently accepted scientific paradigm views an ecosystem as a "complex, constantly changing mosaic that never reaches a true equilibrium state."[105] The changes are unpredictable and subject to external events, such that researchers never obtain a "definitive" understanding of the system.[106] Thankfully, prediction markets do not come to conclusions, but instead constantly add layers of knowledge as traders continually perform research in pursuit of profit. This stream of feedback allows the agency to revise policies in accord with current consensus as it adjusts to the caprices of ecological reality.[107] Furthermore, prediction markets place a premium on analyzing ecological change as quickly as possible—the first to trade on "inside information" often makes the bulk of the profit. Such haste is useful because some ecological changes, like a forest fire that suddenly leaves a species in a perilous state,[108] demand an immediate policy response in the form of an emergency listing or critical habitat designation.[109]

104. Ruhl, *supra* note 95, at 570.

105. Carden, *supra* note 69, at 242.

106. *Id.*

107. *See* Hahn & Tetlock, *supra* note 18, at 263 (asserting that prediction markets can provide updated information in "something that approximates real time").

108. Island species are especially vulnerable to extinction through random demographic or environment effects because of their small numbers. *See* Marco Restani & John M. Marzluff, *Funding Extinction? Biological Needs and Political Realities in the Allocation of Resources to Endangered Species Recovery*, 52 BioScience 169, 172 (2002).

109. 16 U.S.C. § 1533(7) (2006) (allowing the Secretary to skip a number of procedural steps that normally precede new regulations if he is faced with "any emergency posing a significant risk to the well-being of any species").

C. Applying Prediction Markets to Economic Data Gaps

Citizens possess information that potentially enables them to more accurately assess the cost of regulatory actions than the government's current scheme. They can do so effectively via a prediction market.[110] First, citizens have more knowledge of local enforcement practices. Costs resulting from the application of Section 7, which requires federal agencies to consult with the FWS to insure that certain actions do not threaten endangered species, vary as a result of erratic enforcement.[111] Since enforcement decisions are ultimately determined by FWS officials in regional offices, local developers are best positioned to predict the whims of these local bureaucrats and hence can disclose valuable information to the marketplace when evaluating policy decisions that affect species in the area.

In addition, citizens can better assess enforcement cost due to their ability to more accurately predict the pace of real estate development in the relevant area. Real estate growth rates are far from uniform and vary based on factors such as physical constraints on developable land, the amount of preexisting development, competing non-urban uses, and local zoning ordinances and growth controls.[112] All of these variables represent areas of knowledge uniquely within the purview of local developers, and these citizens can probably estimate how the variables will shift over time. Also, development is often "lumpy" in the sense that much of the new development in a given region might be encapsulated in a single project.[113] In such a situation, knowledge of the developer's plans becomes particularly important in projecting enforcement costs:

110. There is nearly universal agreement that the ESA is not administered in a cost-effective manner. *See, e.g.*, Jason F. Shogren, *Benefits and Costs*, *in* 2 THE ENDANGERED SPECIES ACT AT THIRTY, *supra* note 66, at 181, 181; Jonathan Remy Nash, *Trading Species: A New Direction for Habitat Trading Programs*, 32 COLUM. J. ENVTL. L. 1, 9 (2007); Wyman, *supra* note 45, at 518–23 (discussing requiring the FWS to identify the most cost-effective ways of protecting a species after it is listed). As previously discussed, the FWS is statutorily prohibited from considering cost when making listing decisions, but it is obligated to consider the "economic impact" of critical habitat designations. *See supra* note 49 and accompanying text. Unfortunately, the Service's economic analyses are often plagued by numerous information gaps, which will be discussed in detail below. *See infra* Part IV.B.

111. *See* Moore, *supra* note 66, at 171 (emphasizing the agency's discretionary enforcement of Section 7); Wyman, *supra* note 45, at 503–06 (arguing that estimates of cost are skewed by anecdotal "horror stories" because the FWS rarely enforces Section 7 or 9 to the fullest extent possible).

112. David L Sunding, *Economic Impacts*, *in* 2 THE ENDANGERED SPECIES ACT AT THIRTY, *supra* note 66, at 190, 204.

113. *Id.* at 194.

prediction markets incentivize the developer himself to reveal those plans.

Although prediction markets used in the environmental context would be primarily targeted towards improving critical habitat designations, they might incidentally encourage private individuals to behave more prudently. As it currently stands, land use regulations effectuated by the ESA create a number of perverse incentives. For example, landowners are often encouraged to inefficiently rush development before their property is designated as a critical habitat.[114] If this option is unavailable, landowners have been known to simply destroy the species' habitat to preempt regulation.[115] Both of these practices are in part a result of landowners' exaggerated fears of the magnitude and likelihood of land use regulation.[116] Therefore, prediction markets might mitigate inefficient practices simply by providing landowners with objective information, inferred from the prediction markets, concerning the chances of regulation and its projected costs—information that may convince landowners that their fears are exaggerated hinder a potentially irrational response.[117]

The availability of the prediction exchange might also alleviate the need to rush development in the first place. Imagine a landowner who plans to construct a hotel in Area A in three years' time, but is worried that the FWS might first list that area as part of an endangered species' critical habitat. However, the FWS would exclude Area A from the animal's critical habitat if the construction of the hotel were to commence before the designation, as it would realize that the regulatory imposition would be significant. Naturally, the landowner might inefficiently rush construction rather

114. *See* Adler, *supra* note 55, at 317–19; Geoffrey K. Turnbull, *The Investment Incentive Effects of Land Use Regulations*, 31 J. REAL EST. FIN. & ECON. 357, 369 (2005) ("Once a particular tract of land is developed, the irreversibility of land improvements erases any remaining threat of this kind of regulation for the tract.").

115. *See* Adler, *supra* note 55, at 320–31 (providing empirical and anecdotal evidence documenting the problem).

116. *See* Wyman, *supra* note 45, at 506 ("Although often called the pit bull of environmental laws, the ESA may in reality be a paper tiger given the extent to which it is not enforced in many cases. But the perception that the ESA is a pit bull itself is costly."). Professor Elmendorf thinks that such overreactions may be tied to a spiteful urge to retaliate against the green movement. Elmendorf, *supra* note 73, at 433.

117. Of course, it is possible that the prediction markets could exacerbate landowners' fears in some circumstances. However, since landowner's usually overestimate rather than underestimate the costs and likelihood of regulation, the markets still should produce a positive effect in the aggregate.

than leave the designation to the caprices of FWS bureaucrats.[118] With the availability of a prediction exchange, the landowner can instead send a credible signal that he plans construction in the near future: he simply places a large bet forecasting high regulatory costs associated with Area A.[119] If the FWS develops a reputation for respecting such results, the landowner can rest assured that Area A will remain unregulated without having to bear the cost of rushed development. The bet is credible because the landowner risks financial loss in the absence of construction; in that case, regulatory costs would be much lower than predicted, and he would suffer a large loss on the bet. In this sense, the bet is akin to recoverable collateral if the landowner does not fulfill his guarantee to construct the hotel.

A problem could arise if the landowner realizes that the regulatory costs would be too insignificant to forestall regulation: he might opt to exaggerate his project's scale, figuring that the inaccuracy of his prediction will be compensated for by the better regulatory environment that it produces. However, this plan falls apart if other market participants discover A's true plans, and there is reason to think that prediction markets are successful at uncovering such intentions.[120] Furthermore, the FWS can make special efforts to punish deception as a deterrent. For instance, in the above hypothetical, the agency could revise their initial critical habitat designation to include Area A in order to deny the landowner any

118. As it currently stands, the FWS has limited appetite for assessing the costs of projects that would commence in the distant future, unless those projects are already authorized or publicized. S*ee, e.g.*, U.S. FISH & WILDLIFE SERV., FINAL DRAFT ECONOMIC ANALYSIS OF CRITICAL HABITAT DESIGNATION FOR THE SANTA CRUZ TARPLANT 10 (*prepared by* Industrial Economics, Inc., 2002), *available at* http://www.fws.gov/pacific/news/2002/pdf/0411tar.pdf ("This report estimates impacts of listing and critical habitat designation on activities that are 'reasonably foreseeable,' including, but not limited to, activities that are currently authorized, permitted, or funded, or for which proposed plans are currently available to the public.").

119. Of course, this scenario requires that Area A be sufficiently small such that costs associated with the landowner's project would make up a significant portion of the overall costs connected with designation.

120. *See infra* notes 195–200 and accompanying text. Because a landowner must disclose his identity when placing bets, this form of manipulation would seem particularly tough to disguise. A landowner's bet that acts to deter regulation of the landowner's property would raise an immediate cloud of suspicion, prompting other market participants to further investigate the bet's credibility.

benefit from his deception,[121] although this would be costly if the need arose on a frequent basis.

III.
STRUCTURING PREDICTION MARKETS

A. Establishing the Exchange

This subsection details how the FWS could establish a prediction market to collect scientific information.[122] However, much of the discussion can be generalized to a market that would collect economic data as well.

First, the agency would set up an exchange and take responsibility for monitoring, maintenance, legal controls, and any other necessities.[123] It would then establish a contract for each species for which data is needed. Since the ESA assumes that losses short of extinction are relatively insignificant,[124] the logical prediction market metric is the chance of extinction, rather than an intermediate measure. The contract would pay out fully if the species becomes extinct within a certain time frame, and the market price of the contract would represent the chances of extinction for that time frame. The relevant time period would have to be sufficiently long to produce non-negligible probabilities, perhaps ten years, although the time frame would vary depending on the species. A long time period might necessitate the posting of collateral when

121. The ESA grants the FWS authority to revise designations from time to time as appropriate. 16 U.S.C. § 1533(a)(3)(A) (2006).

122. The ESA might have to be amended such that the FWS could take full advantage of the data utilized by prediction markets. It is unclear whether market data would qualify as the "best scientific data available" such that it could be relied upon by the agency when making listing decisions. A comprehensive analysis of this matter is beyond the scope of this Note. However, courts do seem to offer significant deference as to what constitutes "best available science." They have opined that the requirement "merely prohibits [an agency] from disregarding available scientific evidence that is in some way better than the evidence [it] relies on." Kern County Farm Bureau v. Allen, 450 F.3d 1072, 1080 (9th Cir. 2006) (quoting Sw. Ctr. for Biological Diversity v. Babbit, 215 F.3d 58, 60 (D.C. Cir. 2000)) (alterations in original). A commentator has suggested that the "best available science" definition imposes little that is not already required under the Administrative Procedure Act. *See* Doremus, *supra* note 97, at 423.

123. *See* Hahn & Tetlock, *supra* note 18, at 266–67. Presumably, the agency would contract this task to a consulting service, such as NewsFutures, that possesses experience in establishing prediction exchanges for private enterprises.

124. *See* Stephen Polasky & Holly Doremus, *When the Truth Hurts: Endangered Species Policy on Private Land with Imperfect Information*, 35 J. ENVTL. ECON. & MGMT. 22, 43 (1998). However, the ESA might disvalue losses to the extent that they make the species' full recovery less likely.

purchasing or short selling a contract, but the collateral could be invested in treasuries so as not to discourage traders concerned with the time value of money.[125]

The agency should post all of its field data and modeling exercises online so that it would be easily accessible to potential bettors; bettors could then build off this data (if the market judges it valid) rather than replicating it. Furthermore, as a condition for trading on the market, bettors should be required to post any relevant data on which they relied, particularly sightings of species, subsequent to making that bet. This information is crucial to the agency for planning recovery programs and enforcement activities; it also adds to the foundation of knowledge upon which other betters rely. Although this provision might be difficult to enforce, it is actually consistent with the bettors' self interest. Assuming the information is relevant and valid, the market price of the contract will change in the direction of the trader's bet following public disclosure—this allows the trader to cash out from his position and instantly realize gains, rather than waiting until the end of the contract period, which may be years away, for payout. Cashing out immediately also negates the risk that additional information will emerge that is adverse to the trader's betting position.[126]

A potential problem is that prediction markets are subject to a circularity problem.[127] Traders know that if the market were to indicate a high chance of extinction for a given species, the FWS will likely react with ameliorative policy measures designed to lower the risk. Consequently, the probability will never rise in the first place, stripping the market of its functionality.

One means of circumventing this problem is through the use of conditional markets.[128] Under this scheme, the agency would issue two securities for each species. One contract would pay out in the event of a certain policy action (and the fulfillment of the contract condition) and the other if that course of action is not taken. For example, one contract might indicate a one percent chance of extinction if the Secretary lists a species as endangered, while an-

125. *See* Abramowicz & Henderson, *supra* note 4, at 1380.

126. Of course, there might be countervailing incentives that would cause a trader not to disclose information. More empirical evidence concerning the activities of traders participating in prediction markets is needed to substantiate my hypothesis.

127. *See* Abramowicz, *supra* note 8, at 985; Abramowicz & Henderson, *supra* note 4, at 1353; Sunstein, *supra* note 4, at 1042 n.387.

128. This scheme is based on a method discussed by Hahn and Tetlock, *see* Hahn & Tetlock, *supra* note 18, at 239, but other proposals are discussed throughout the literature. *See, e.g.*, Abramowicz & Henderson, *supra* note 4, at 1353–54.

other contract would demonstrate a five percent extinction risk if no listing occurs.[129] Taken together, these prices indicate that a listing would reduce the probability of extinction by four percent and would hence be quite valuable. If the Secretary ultimately decided to pursue a listing, then the first contract would stay valid and would pay out in the event of extinction, while the latter would be unwound, meaning that all bets would be nullified and collateral returned to the original owners.[130]

B. Alternative Metrics

This proposal is subject to two flaws, which may undermine its viability. First, extinctions are difficult to definitively ascertain and often take years to verify.[131] Of course, time brings greater certainty, but even a ten-year time horizon would strain the bettors' patience. Thus, as an alternative to betting on extinction, traders could predict whether a species is expected to achieve "critical status" as determined by a designated FWS employee. Such a determination would be in accord with preset rigid guidelines and would indicate that the species is perilously close to extinction. Even if this process introduces a modicum of subjectivity, the market should remain functional as long as certain conditions are met.[132]

The second problem arises from the rarity of extinction. For many species, the possibility of extinction is sufficiently remote that the security price is close to zero (although still nonnegligible). Gleaning information from such prices is difficult because of the inevitable occurrence of "noise," or random fluctuations, during the lifespan of the security.[133] For instance, it might be difficult to assess whether a doubling in contract price represents a doubling in risk or simply a random fluctuation (because the price increase would represent such a small increase in absolute value). When multiple contract prices must be analyzed, as is the case with condi-

129. To further clarify, the first contract would only pay out if the species is listed *and* it goes extinct, while the second would pay out only if the species is not listed and it goes extinct. If a trader strongly believed that the species would go extinct, he would probably purchase both contracts, so as not to be subject to the whims of the government. However, he would not be obligated to purchase the contracts in tandem.

130. *See* Abramowicz & Henderson, *supra* note 4, at 1353.

131. *See* Doremus, *supra* 66, at 1121 ("[O]nly in rare cases, when all individual members of a species are known, is it clear when the last death occurs."). Sometimes species are considered extinct only to be subsequently rediscovered. *See, e.g.*, Scott et al., *supra* note 42, at 31.

132. *See infra* notes 138 and 140.

133. *See* Abramowicz, *supra* note 8, at 956.

tional markets, the problem is further magnified. Also, traders would need to invest very large sums of money in order to make sizeable profits because even important information disclosures would likely result in very small price movements. Such capital requirements would make market participation impractical for many individuals concerned with liquidity or risk.[134]

An alternative scheme would have bettors predict the species' population size at the end of a given time period, contingent on a particular policy action. For each contingency (whether or not the policy is pursued), the agency would issue a series of security classes designed to elicit a probability distribution.[135] For example, one security would pay out in the instance of 0–5000 population size, another in the event of 5000–20,000, and another if the species were to number more than 20,000. The implied probabilities of the three securities should add to one, indicating that one contract is bound to pay out. The agency could adjust the number of securities classes and payout conditions depending on current population numbers and the information needed to determine policy success.

The scheme's advantage is that the payout conditions could inevitably be manipulated to produce nontrivial probabilities, eliminating the noise problem. Moreover, this information is probably more useful when the species' extinction is not a serious threat—it enables the FWS to decide which actions can be taken to lift species' numbers to the point of self sufficiency, which helps effectuate the ESA's second goal of ensuring species survival absent ESA safeguards. Of course, population size also serves as a proxy, although an imperfect one, for extinction risk.[136] Another advantage is the potential to issue contracts associated with shorter time periods,

134. For a potential solution to this problem, *see infra* Part V.C for a discussion of liquidity constraints and risk aversion and possible solutions.

135. The same approach is utilized by Intrade to generate predictions on non-binary outcomes. *See, e.g.*, Intrade Prediction Markets, http://www.intrade.com (follow "Financial," then "Dow Jones Index") (last visited Mar. 30, 2010). This scheme also facilitates the "market scoring rule," which is discussed later. *See infra* notes 186–194 and accompanying text.

136. *See* Moore, *supra* note 66, at 141 ("Although the certainty of a species' long term survival is impossible to gauge with mathematical equation, the probability of its survival predictably rises as its abundance and range increase."). Other factors which influence extinction risk include population growth rate, variability in population growth rate over time, the number of demographically independent species populations and, human behavior. *See* Ruckelshaus & Darm, *supra* note 66, at 109, 111. However, many of these other factors may be devised from changes in the market values over time, and from the evidence submitted in conjunction with bets.

since most species will dwindle in numbers long before they become extinct.

The disadvantage is that population size is not an objectively knowable fact in the sense that it is easily observable or verifiable; rather, any population-size figure is essentially an estimate based upon a mixture of field data and modeling assumptions.[137] Yet this fact alone would not erase the market's vitality. After the expiration of the relevant contract, the FWS could select an expert evaluator at random to analyze all compiled data, including the information posted by bettors.[138] He would then issue a finding which determines payouts.

Under this scenario, the market price would represent a prediction of the evaluator's likely determination rather than empirical reality. Yet traders still have equal incentive to gather field data because it would affect the evaluator's projections. Bettors are subject to the chance that the evaluator will read the evidence haphazardly or let ideology interfere or make a blind guess due to the lack of data. However, the market predicts the estimate of an average evaluator, rather than the particular evaluator chosen, and given that these fluctuations roughly cancel out in the aggregate, the market maintains objectivity.[139]

To help insure independence, the evaluator could receive similar protections as that of an administrative law judge.[140] For example, she might only be removed for good cause as established by an external commission and ex parte contacts between the evaluator and judge could be prohibited.

C. Estimating Cost

The structure of a prediction market forecasting economic data will be similar to that of one predicting scientific data. The

137. *See* Doremus, *supra* note 66, at 1119.

138. The following approach is loosely based on Michael Abramowicz's proposal to establish prediction markets to estimate the results of a cost-benefit analysis. *See* Abramowicz, *supra* note 8, at 997–1003. Like a cost-benefit analysis, population estimates are grounded in empirical reality, but necessarily somewhat subjective in character. But while Abramowicz sees the primary benefit of his project as enhanced objectivity, my scheme's chief function is information discovery. *Id.* at 1003.

139. *See id.*

140. Administrative law judges (ALJ) presiding over Social Security hearings bear some resemblance to the evaluators I envision. Like these ALJs, FWS evaluators would collect evidence, issue decisions, and oversee a fundamentally inquisitive (as opposed to adversarial) process. *See* Snead v. Barnhart, 360 F.3d 834, 838 (8th Cir. 2004).

FWS would issue contracts requiring prediction of the costs that can be directly traced to environmental regulation in a specific area. Again, two contingent securities would be issued: one asking bettors to predict total costs in a geographic area in the event that it is designated as critical habitat, and one in the event that it is not. The costs resulting from the designation would then be implied from the spread between the securities.[141] Contracts would likely ask for predictions of costs in the ten years subsequent to the critical habitat designation, as this is the time frame currently utilized by the FWS when issuing economic impact assessments.[142]

The main weakness of the cost metric is the introduction of significant subjectivity, but again the problem can be dealt with through the random appointment of an independent evaluator. However, compared with determinations of population size, estimations of cost present a greater challenge because of the presence of line-drawing problems. While it is relatively obvious (at least to a scientist) what it means to be a member of a listed species, the same cannot be said for directly attributable cost. For example, is inefficient delay caused by the regulatory uncertainty that follows a delay a direct or indirect cost? A business whose valued supplier goes bankrupt due to regulation?

Still, this problem is not insurmountable: the FWS could simply issue binding guidelines that address the most common line-draw-

141. Under an alternative approach, the FWS could issue a single security designed to estimate all costs caused by the relevant regulation (bets would be unwound if the regulation did not come about). The problem with this approach is that in a world of overlapping regulations, causation is not always clear. *See* Sunding, *supra* note 112, at 191 ("[L]and development can be subject to multiple environmental regulations, and for more than one endangered species. The cumulative effect is likely to be larger than the sum of individual effects."). So for example, say that a critical habitat designation for Species A brings about $10,000 in additional costs, but it would only have cost $7,000 if not for coexistent protection of Species B. It is not clear that the Species A designation is the proximate cause of all $10,000, as Species B regulation is a but-for cause of $3,000. These types of problems might arise frequently because seventy-two percent of endangered species are concentrated in just six states. Scott et al., *supra* note 42, at 20.

142. *See* Amy Sinden, *The Economics of Endangered Species: Why Less is More in the Economic Analysis of Critical Habitat Designations*, 28 HARV. ENVTL. L. REV. 129, 176 n.209 (2004) ("Almost all of the economic analyses limit the time horizon to ten years"). In connection with the statutory requirement, FWS contracts out the preparation of economic impact assessments to estimate the likely affects of critical habitat designations. *See, e.g.*, INDUSTRIAL ECONOMICS, INC., FINAL ECONOMIC ANALYSIS OF CRITICAL HABITAT DESIGNATION FOR THE FISH SLOUGH MILK-VETCH (2005), *available at* http://www.fws.gov/economics/Critical%20Habitat/ESA%20Reports%20as%20of%20August%202005/Fish%20slough%20milk-vetch/Final%20Report/FSMV%20Final%20EA%205-26-05.pdf.

ing dilemmas. Furthermore, the evaluators could issue short opinions resolving any remaining ambiguities, which would gradually develop into a coherent jurisprudence. Like the contracts measuring animal population size, these contracts would be structured to elicit a probability distribution showing the chances of costs falling within a particular range. Traders would be rewarded if they bet on the correct range. Therefore, most minor ambiguities would not affect contract payouts anyway.[143]

IV.
APPLYING PREDICTION MARKETS TO POLICY ACTIONS

A. Listing Decisions

The decision to list an imperiled species as "endangered" or "threatened" significantly affects a species' chances of survival and can forewarn of a heavy economic burden. With so much at stake, one might expect the Secretary to carefully consider all of the relevant evidence; in fact, the decision-making process is chaotic and chronically underfunded. In regard to the latter point, some estimate that the number of listed species amounts to only ten to twenty percent of the total number of imperiled species.[144] However, during fiscal year 2008, the FWS appropriated a mere $8,207,000 for new listings, and it is unlikely the FWS could list the additional species without significantly greater resources.[145] To make matters worse, the process for allocating the FWS's limited funding is not driven by need. The majority of the allocation is

143. If current practice is any guide, market participants will not be able to produce estimates with excessive precision, so the probability distribution would likely feature broad intervals, further minimizing the effect of minor ambiguities.

144. Frank W. Davis et al., *Renewing the Conservation Commitment*, *in* 1 THE ENDANGERED SPECIES ACT AT THIRTY, *supra* note 42, at 296, 297 (estimating that the ESA covers only fifteen to twenty percent of imperiled species); David S. Wilcove & Lawrence L. Master, *How Many Endangered Species Are There in the United States?*, 3 FRONTIERS IN ECOLOGY & ENV'T 414 (2005) (concluding that the Act covers less than ten percent of imperiled species).

145. *See* Review of Native Species that are Candidates for Listing as Endangered or Threatened, 73 Fed. Reg. 75,176, 75,185–86 (Dec. 10, 2008) (to be codified at 50 C.F.R. pt. 17) [hereinafter Candidates for Listing] (stating the listing budget and the various activities that it must fund); D. Noah Greenwald et al., *The Listing Record*, *in* 1 THE ENDANGERED SPECIES ACT AT THIRTY, *supra* note 42, at 51, 64 (stating that the FWS estimates $153 million is necessary to address listing backlogs); Wyman, *supra* note 45, at 496. However, this appropriation represents a reasonable increase over last year's budget of roughly $5,200,000. *See* Review of Native Species that Are Candidates for Listing as Endangered or Threatened, 72 Fed. Reg. 69,034, 69,050 (Dec. 6, 2007) (to be codified at 50 C.F.R. pt. 17).

devoted to "court mandated listing activities,"[146] and empirical evidence cautions against the notion that interest groups sue on behalf of the most vulnerable species.[147] Congressional politics also play a role: listing decisions are affected by the current membership of the oversight committee and which imperiled species reside in their respective states.[148] For its part, the FWS refuses to formulate explicit listing standards, which could at least address the blatantly inconsistent decisions that often arise under current processes.[149]

Of course, citizens can prompt the FWS to consider listing vulnerable species by filing a petition;[150] unfortunately, they cannot expect a response within a reasonable amount of time. The FWS is statutorily obligated to issue a decision within two years, but the agency frequently circumvents that timeline by listing the species as a "candidate" or issuing a "not practicable" finding.[151] Between 1974 and 2003, it has taken the FWS an average of eleven years to list a species, and listing rates have steadily declined since 1996.[152] Moreover, these delays are not just a matter of inconvenience: forty-two species have become extinct while awaiting a final decision.[153] Obviously, these delays are partly driven by a lack of adequate funding, but they also result from uncertainty surrounding the species' viability and concern over a listing's economic impact.[154]

A prediction market would be an efficient means for adding rationality to the listing process. The FWS could issue contingent contracts designed to assess the impact for a species if a listing were to occur within a short period of time. It would be infeasible to

146. *See* Wyman, *supra* note 45, at 496.

147. *See* Restani & Marzluff, *supra* note 108, at 173–74 (finding that interest groups are much more likely to sue to protect threatened species, rather than endangered ones).

148. *See* J.R. DeShazo & Jody Freeman, *Congressional Politics*, *in* 1 THE ENDANGERED SPECIES ACT AT THIRTY, *supra* note 42, at 68, 68–69; *see also* Doremus, *supra* note 66, at 1122–27 (arguing that the ambiguity of viability standards will inevitably lead to political meddling).

149. Doremus, *supra* note 66, at 1124.

150. *See* 16 U.S.C. § 1533(b)(3) (2006).

151. Greenwald et al., *supra* note 145, at 60–61.

152. *Id.* at 55 fig.5.1, 62.

153. *Id.* at 51. The authors also point out that species often are not listed until they are near extinction, which lowers their chance of survival and makes recovery efforts more expensive. *Id.* at 62–63.

154. *See* U.S. GEN. ACCOUNTING OFFICE, ENDANGERED SPECIES: FACTORS ASSOCIATED WITH DELAYED LISTING DECISIONS, GAO/RCED-93-152, at 7–8 (2003), *available at* http://archive.gao.gov/t2pbat5/149751.pdf (discussing specific instances where questions about the sufficiency of biological data and concerns about the economic impacts of listings delayed listing decisions).

issue contracts for each of the thousands of species that may be at risk;[155] however, the FWS could issue contracts for each of its candidate species (currently there are 251),[156] or in response to an outside petition.

Prediction market data would be of great use to conservation-oriented interest groups when deciding what litigation to pursue. These groups sometimes sue for the protection of hundreds of species all at once,[157] but such broad suits might be counterproductive because they increase the immense listing backlog at the FWS.[158] The information provided by prediction markets would allow interest groups to only sue on behalf of the neediest species. This strategy enables the interest group to achieve the most good with its potentially limited resources, but it also insures a better allocation of the FWS's own listing funds since appropriations are so heavily influenced by outside litigation.[159]

Prediction markets might also affect listing decisions indirectly by altering public and congressional opinions. This Note has previously detailed how prediction markets elucidate divergences between agency policy and academic or commercial consensus.[160] An interest group could use market data to demonstrate that the FWS is failing to protect a species that is most in need of aid and could use this simple presentation to rally public support—it might even accuse the FWS of ignoring the will of the people as expressed through the prediction market. If public opinion firmly supports or opposes a listing, it is likely to affect the views of those politically powerful legislators who have been shown to carry influence over the FWS's listing decisions. However, if public opinion is polarized, the politician might also gravitate towards market consensus because it provides political cover: rather than offend one side of the debate, she can characterize her position as deference to expertise.

155. Experts estimate the FWS has managed to list only a small percentage of the species that are truly in danger. *See supra* note 144 and accompanying text.

156. Candidates for Listing, *supra* note 145, at 75,177. A candidate species is one "for which the Service has on file sufficient information on biological vulnerability and threat(s) to support issuance of a proposed rule to list, but for which issuance of the proposed rule is precluded." *Id.* at 75,183–84.

157. *See, e.g.*, Juliet Eilperin, *Since '01, Guarding Species is Harder; Endangered Listings Drop Under Bush*, WASH. POST, Mar. 23, 2008, at A1 ("WildEarth Guardians filed a lawsuit Wednesday seeking a court order to protect 681 Western species all at once.").

158. *See supra* notes 150–54 and accompanying text.

159. *Id.*

160. *See supra* pp. 109–110.

Finally, even if the FWS could not legally consider contract prices under the ESA,[161] it could certainly make use of the scientific evidence that traders are required to submit in conjunction with their bets. So if the market were to indicate that a species is prone to an especially high risk of extinction, the FWS could immediately examine the submitted evidence with special care and make a listing decision based on the review. If the risk of extinction were especially high, the agency could expedite the listing process for that species so that it does not fall prey to extinction before regulation takes effect. Under this practice, the agency can use the market as a means of contracting out the gathering of information and as a signaling device to determine where agency manpower should be allocated. By mostly ignoring contract prices, the agency loses out on the objectivity enhancing function of the market, but this function can be replicated by outside litigants and politicians who do pay attention to market data.

B. Critical Habitat Designations

Recall that the principal effect of a critical habitat designation is to affect actions authorized, funded, or carried out by a federal agency. Under Section 7, federal agencies may not take any action that is likely to "result in the destruction or adverse modification" of the critical habitat of a listed species, and agencies whose actions "will likely affect" a species must "consult" with the FWS to ensure compliance.[162] FWS formerly maintained that critical habitat designations are wholly superfluous because Section 7 already prohibits all federal actions that would "jeopardize" the "continued existence" of a listed species.[163] However, in 2001, the Fifth Circuit ruled that the agency's interpretation contravenes congressional intent by equivocating the two standards, and that "adverse modification" is related to the concept of "conservation;" therefore, there is a broader duty than if the agency merely had to ensure the species' survival.[164]

161. *See supra* note 122 (analyzing whether the FWS's use of prediction-market data would violate the statute requiring the FWS to rely on the "best scientific data available" when making listing determinations).

162. 16 U.S.C. § 1536(a) (2006).

163. *See, e.g.*, Sierra Club v. U.S. Fish & Wildlife Serv., 245 F.3d 434, 439 (5th Cir. 2001).

164. *Id.* at 441–42; s*ee also* Gifford Pinchot Task Force v. U.S. Fish & Wildlife Serv., 378 F.3d 1059, 1070 (9th Cir. 2004) (also holding that the agency's interpretation contravenes congressional intent). The agency abandoned its interpretation following these two decisions. *See, e.g.*, Revised Proposed Designation of Critical Habitat for 12 Species of Picture-Wing Flies from the Hawaiian Islands, 72

Despite the FWS' former position and the apparent linguistic similarity between the "adverse modification" and "jeopardy" standards, the effects of a critical habitat designation are real and significant. Oliver Houck notes that courts are much more likely to enjoin development activity when a critical habitat has been designated. "[T]he ESA's prohibition on modification of critical habitat is interpreted by courts as strong and unyielding; the prohibition on jeopardy is viewed as discretionary and flexible."[165] Anecdotal evidence confirms that federal agencies agree with this proposition.[166] Furthermore, the National Research Council considers the "adverse modification" standard more objective and quantifiable and therefore easier to prove in court.[167] Finally, local agencies often interpret a critical habitat designation as a signal to tighten up their own land use regulations, especially when they are relatively under-informed.[168] Therefore, the large economic impact associated with designation, albeit hard to quantify, should indicate that habitats should be drawn with the utmost care.

In practice, this is hardly the case. The agency tends to resort to overly broad designations because of the high cost of narrower tailoring and to ensure that all species are included.[169] The latter cause might be further traced to information deficits. For example, the agency is statutorily obligated to designate a habitat at the time of listing, but it possesses almost no information about the location of animal populations at this time, causing it to resort to breadth in

Fed. Reg. 67,428, 67,442 (proposed Nov. 28, 2007) (to be codified 50 C.F.R. pt. 17).

165. Oliver A. Houck, *The Endangered Species Act and Its Implementation by the U.S. Departments of Interior and Commerce*, 64 U. COLO. L. REV. 277, 310 (1993).

166. *See* Sinden, *supra* note 142, at 164 (describing how the Environmental Protection Agency and Army Corps of Engineers terminated costly consultation activities after a court vacated the pygmy owl critical habitat designation).

167. *See* NAT'L RESEARCH COUNCIL, SCIENCE AND THE ENDANGERED SPECIES ACT 76 (1995).

168. Sunding, *supra* note 112, at 191.

169. Murray D. Feldman & Michael J. Brennan, *The Growing Importance of Critical Habitat for Species Conservation*, 16 NAT. RESOURCES & ENV'T 88, 92 (2001); *see, e.g.*, Cape Hatteras Access Pres. Alliance v. U.S. Dep't. of the Interior, 344 F. Supp. 2d 108, 122 (D.D.C. 2004) (FWS argued an overbroad designation was required in part because of the lack of sufficient data). Note that countervailing political pressures and the threat of lawsuits from landowner groups may counsel the FWS against overbroad designations in some instances. *See, e.g.*, Press Release, Pacific Legal Foundation, Overbroad Bighorn Sheep Habitat is Reduced, Following PLF Legal Action, (Apr. 14, 2009), *available at* http://community.pacificlegal.org/Page.aspx?pid=869.

designations.[170] One would think that the statutory command to consider "economic impact" would act as a check on this practice. However, the agency's means of taking direct cost into account are highly imperfect,[171] and it rarely even attempts to consider secondary economic effects.[172] Even when the agency does identify significant expenses, it possesses no reliable means of comparing costs and benefits.[173] Instead, the agency almost always declares that the

170. *See* Jason M. Patlis, *Paying Tribute to Joseph Heller with the Endangered Species Act: When Critical Habitat Isn't*, 20 STAN. ENVTL. L.J. 133, 206 (2001).

171. The FWS produces an "economic impact assessment" in connection with each designation. Under one approach, the agency relies upon computer models incorporating estimates of demographic and regulatory changes to predict future residential, commercial, and industrial development. *See* Sinden, *supra* note 142, at 176–77 (citing U.S. FISH & WILDLIFE SERV., DRAFT ECONOMIC ANALYSIS OF CRITICAL HABITAT DESIGNATION FOR THE SAN BERNARDINO KANGAROO RAT ES-6 (*prepared by* Industrial Economics, Inc., 2001) [hereinafter KANGAROO RAT]). It then translates its prediction into an estimate of the number of Section 7 consultations that will be required, from which it infers the costs stemming from the consultations, both in terms of project modifications and "per effort" costs. *Id.* at 177–78. Finally, the agency tries to separate out those costs that would still be present under the "jeopardy" standard in order to isolate the effect of the critical habitat designation. *Id.* at 178–79. In moving from one estimate to the next, the FWS sometimes relies on empirical data: for example, it might look at historical patterns to determine the percentage of future consultations that will require project modification. *See, e.g.*, KANGAROO RAT, *supra*, at 100 (relying on records of past kangaroo rat consultations). But sometimes it will employ similar assumptions with little explanation and minimal consultation with experts. *See, e.g.*, Ctr. for Biological Diversity v. Bureau of Land Mgmt., 422 F. Supp. 2d 1115, 1149 (N.D. Cal. 2006); KANGAROO RAT, *supra*, at 100 (stating that the percentage of projects that are likely to have a federal nexus is "difficult to determine," then generating an estimate based entirely on "conservations with the [Army Corps of Engineers]" and the number of waterways in the area). Even when data is used, the fact that so many assumptions are required makes the overall result sensitive to reasonable adjustments of the underlying postulations. Sinden, *supra* note 142, at 179.

172. *See* Sinden, *supra* note 142, at 201. Measurement of secondary effects is an extremely complicated task, *see id.*, and most analyses that have tried have reached only tentative conclusions. *See, e.g.*, Endangered and Threatened Wildlife and Plants; Final Designation and Nondesignation of Critical Habitat for 46 Plant Species From the Island of Hawaii, HI, 68 Fed. Reg. 39,624, 39,681 (July 2, 2003) (to be codified at 50 C.F.R. pt. 17) ("While our final economic analysis includes an evaluation of potential indirect costs . . . some types of costs are unquantifiable.").

173. *See* Sinden, *supra* note 142, at 183; Ronny Millen & Christopher L. Burdett, Note, *Critical Habitat in the Balance: Science, Economics, and Other Relevant Factors*, 7 MINN. J. L. SCI. & TECH. 227, 277 (2005) ("FWS's practice of comparing quantitative estimates of the costs of designating critical habitat with qualitative estimates of habitat benefits ignores this inherent mismatch."). The FWS has shown an increased willingness to use contingent valuation surveys, but such devices are highly controversial. *See* CHARLES D. KOLSTAD, ENVIRONMENTAL ECONOMICS 364 (1999).

costs are "not significant" whether they number in the thousands or hundreds of millions.[174]

All of the criticisms listed above have led to heavy discontent with the current designation process.[175] Fundamental flaws in the system must be cured by statute, but prediction markets can at least help to fill the information gaps currently crippling the system. The structure of how such a market would be run is familiar: the FWS would issue economic contracts pertaining to various geographical "units" being considered for designation. The relevant contingency would be the eventuality of designation, and as usual, the gap between parallel contracts would indicate the designation's likely effect.

The implementation of scientific prediction markets for listing purposes would probably provide the agency with a wealth of information on animal locations to begin with; under current practices, much of that information does not arrive until the recovery planning stage.[176] The rapid collection of scientific information insures that critical habitat boundaries can be drawn quickly, at least when that information indicates that expeditiousness is necessary because of the threat of imminent extinction. Furthermore, to the extent that prediction markets produce better information on species location, the FWS can more narrowly tailor critical habit boundaries and thus minimize regulatory burden.

Finally, the market's presentation of scientific data in standardized terms enables the agency to make more consistent tradeoffs between "economic impact" and species harm. The limitations of contingent valuation surveys reinforce the difficulty of comparisons between the two values—any comparison is inherently subjective and doubtless affected by political considerations.[177] However, standardization at least allows the agency to behave consistently and transparently once a tradeoff level has been set.

Because the FWS would have to issue separate contracts for each geographical unit when assessing a designation, cost is a concern. One solution is to only issue contracts in select areas: either

174. Sinden, *supra* note 142, at 183.

175. Craig Manson, the former Assistant Secretary of the Interior, identified it as "broken" during congressional testimony. *A Bill to Amend the Endangered Species Act of 1973 to Reform the Process for Designating Critical Habitat Under That Act: Hearing on H.R. 2933 Before the H. Comm. on Resources*, 108th Cong. 9 (2004) (statement of Craig Manson, Assistant Secretary for Fish, Wildlife & Parks, U.S. Department of the Interior).

176. *See* Patlis, *supra* note 170, at 206.

177. *See* Sinden, *supra* note 142, at 207.

in units where information is sparse or where bureaucrats have reason to suspect that cost will be high. However, critical habitat markets would produce information that is substitutable for the economic impact assessments prepared by consultancies. So if courts determine that market data may fulfill the statutory requirements,[178] or if the ESA is amended, the FWS could potentially save millions in fees. Even if these contingencies do not come to pass, the market would still prove useful: for example, the information submitted in conjunction with bets should prove useful for drafting impact statements and may even eliminate the need to outsource the activity.

V.
POTENTIAL OBJECTIONS

A. Liquidity

The most obvious defect in the framework sketched so far is the possibility of illiquid markets. Liquidity refers to the ability of market participants to execute large transactions with minimal impact on current price, and it is important for several reasons.[179] First, liquidity is needed to obtain a reasonably steady price signal; transaction prices in illiquid markets fluctuate wildly, and any single trade does not necessarily represent market consensus.[180] Second, liquidity enables bettors to profit off of their possession of insider information, which in turn incentivizes bettors to acquire such information.[181] If markets are too thin, bettors will be unable to

178. The FWS is generally given broad discretion when evaluating economic impact. *See* Home Builders Ass'n of N. Cal. v. U.S. Fish & Wildlife Serv., No. CIV. S-05-0629 WBS-GGH, 2006 W.L. 3190518, at *20 (E.D. Cal. Nov. 2, 2006) ("The consideration and weight to be given to any [economic] impact is completely within the Secretary's discretion."). When conducting reviews of economic analyses, courts primarily look to see if the agency "articulates a rational connection between the facts found and choices made," *id.* at *23 (quoting Pac. Coast Fed'n of Fisherman's Ass'ns v. U.S. Bureau of Reclamation, 426 F.3d 1082, 1091 (9th Cir. 2005)), and if critical assumptions have at least some empirical basis, *see* Ctr. for Biological Diversity v. Bureau of Land Mgmt., 422 F. Supp. 2d 1115, 1149 (N.D. Cal. 2006). Both of these requirements would seem to be fulfilled by prediction markets. The FWS "is required to consider the data that it already has in its possession," *id.* at 1153, but assuming that such information is made publicly available, the FWS could argue that it is automatically incorporated into the market. Although I am optimistic that prediction markets would satisfy the statutory standard, I am unable to offer a firm conclusion because of the absence of analogous precedents.

179. Hahn & Tetlock, *supra* note 18, at 251.

180. *Id.*

181. *Id.* at 251–52; *see* Abramowicz, *supra* note 8, at 957.

profit off insider information indicating that a contract is undervalued (or overvalued) because they could not purchase more than a few contracts at the prevailing market price before pushing the price upwards (or downwards).

Without a technical fix, ESA prediction markets will almost surely suffer from a lack of liquidity. The problem is most acute in fledging markets, of which there will be many in a scheme that requires the issuance of new contracts every time a new policy action is contemplated.[182]

There are several potential fixes to the liquidity problem. When evaluating the results of a prediction market, the FWS should look at average transaction prices over a range of time, as opposed to solely focusing on the "market" price, which is the price of the last known transaction.[183] Although this technique partially filters out the "noise" generated in thin markets, it does nothing to address the reduced incentives for traders to discover insider information. To address this latter concern, the FWS will have to encourage more trader participation through subsidies:[184] either direct or indirect. Depending on administrative feasibility, the FWS might offer a "premium" to winning contracts, or they could act as a market maker by offering to buy and sell contracts at slightly more favorable terms than the market would otherwise dictate. Also, the size of the subsidy need not be fixed: it could vary for each contract based on the importance of the information to the agency.[185]

Although a subsidy by itself would be helpful, the liquidity problem could essentially be solved if implemented by means of a "market scoring rule."[186] Under this system, the FWS would first devise a scoring rule to induce participants to bet on what they believe to be the true probability distribution of the events in question—this becomes the standard by which all betters are paid.[187] Scoring rules are well documented in economics literature and often used in practice; they are essentially formulas that adjust payouts for each outcome depending on the participant's stated

182. *See* Hahn & Tetlock, *supra* note 18, at 252.

183. *See* Abramowicz, *supra* note 8, at 946.

184. *See id.* at 960.

185. *See* Abramowicz & Henderson, *supra* note 4, at 1351.

186. The concept was originally devised by Robin Hanson. *See* Robin Hanson, *Combinatorial Information Market Design*, 5 INFO. SYS. FRONTIERS 107 (2003).

187. Abramowicz, *supra* note 8, at 959–60.

probability distribution.[188] After a bettor makes an initial prediction, anyone can make a subsequent prediction as long as the subsequent predictor agrees to pay off the previous predictor according to the scoring rule when the market closes.[189] In turn, this subsequent predictor is paid in accord with the extent that his prediction improves on that of the previous bettor. The process continues until the market closes, and the last predictor is paid by the FWS the amount that he is owed under the scoring rule: this is how the agency would effectively subsidize the market.[190]

The market scoring rule as just described has proven successful in laboratory settings[191] and is currently utilized by a number of online exchanges.[192] The beauty of this technique is that it works effectively even when only a single person bets on a contract. That person is incentivized to state his true prediction via the scoring rule, which rewards accuracy with higher payouts, and to update that prediction as soon as new information becomes available. If she is not quick, she risks another participant entering the market and placing a bet that reflects the new information, thereby denying her the maximum payout.[193] When many bettors participate, the market scoring rule mimics what we think of as a traditional prediction market. From a user interface perspective, the two are identical: in each, the user can buy or sell any number of contracts, with the price changing with each incremental purchase.[194]

188. *Id.* at 959. *See, e.g.*, Robert T. Clemen, *Incentive Contracts and Strictly Proper Scoring Rules*, 11 TEST 167 (2002) (reinterpreting scoring rules in the context of agency theory); Hanson, *supra* note 186, at 109 (outlining the strengths and weaknesses of scoring rules and documenting prior uses); Kenneth C. Lichtendahl Jr. & Robert L. Winkler, *Probability Elicitation, Scoring Rules, and Competition Among Forecasters*, 53 MGMT. SCI. 1745 (2007) (suggesting adjustments to scoring rules to account for competition among forecasters).

189. Abramowicz, *supra* note 8, at 959.

190. *Id.* at 960. Note that the amount of subsidy is effectively determined by the makeup of the scoring rule. *See id.* It cannot be specified exactly ex ante because it is dependent on the accuracy of the final prediction.

191. *See* Ledyard et al., *supra* note 24.

192. *See* Posting of David Pennock to Oddhead Blog, http://blog.oddhead.com/2006/10/30/implementing-hansons-market-maker (Oct. 30, 2006, 11:26 AM) (discussing the use of market scoring in various online contexts).

193. The Market Scoring Rule, http://predictocracy.org/blog/?p=80 (Jan. 23, 2008). The original predictor could still make a bet reflecting the new information after the fact, but it would be less effective, as it would entail the responsibility to pay off the other bettor.

194. Abramowicz & Henderson, *supra* note 4, at 1352. Subsequent bettors will only receive money to the extent that they improve on prior predictions, but the first predictor will always receive income, at least with any scoring rule that always produces a positive reward. Abramowicz, *supra* note 8, at 960. Perhaps the

B. Manipulation

Another worry is that concerned parties such as interest groups or developers might manipulate the markets to suit their policy goals. For example, one could imagine a group of developers pooling money together to place large bets predicting the high costs of regulation in order to forestall such regulation. One check on such strategic behavior is financial: making bets that deviate from empirical reality is costly in the short run. However, some parties might be willing to swallow the cost if the policy in question is particularly important or if the market has limited trading volume, such that shifting the market consensus is relatively cheap. However, the more important check is the presence of other traders. Traders know they can make a profit when manipulative behavior occurs because such conduct opens a gap between a contract's price and fundamental value.[195] The existence of the gap incentivizes traders to invest resources into discovering fundamental value, and hence the attempted manipulation should result in a *more* accurate market price.[196] Empirical research has confirmed this result,[197] and it probably explains why prior attempts at manipulation in online markets have failed.[198] At best, manipulation can succeed in ad-

one flaw in the scheme is the windfall that would be received by the first bettor, which effectively comes out of the agency's pocket. *See id.* at 960. However, even this blemish can be addressed by auctioning off the right to make the first bet or having the agency itself place that bet. *See id.* at 960–61. The latter alternative is especially intriguing because it makes receipt of the subsidy dependent on the extent to which the market improves on the agency's guess. As a result, the FWS would only have to pay out significant sums when they have received a tangible benefit in return.

195. *See* Abramowicz, *supra* note 8, at 973; Hahn & Tetlock, *supra* note 18, at 258; Robin Hanson & Ryan Oprea, *A Manipulator Can Aid Prediction Market Accuracy*, 76 ECONOMICA 304, 311–12 (2008).

196. *See* Abramowicz, *supra* note 8, at 973; Hahn & Tetlock, *supra* note 18, at 258; Hanson & Oprea, *supra* note 195, at 311–12.

197. *See* Robin Hanson et al., *Information Aggregation and Manipulation in an Experimental Market*, 60 J. ECON. BEHAV. & ORG. 449 (showing manipulative trading strategies were unsuccessful in a laboratory setting); Paul W. Rhode & Koleman S. Strumpf, Manipulating Political Stock Markets: A Field Experiment and a Century of Observational Data (June 2008) (unpublished manuscript, *available at* http://www.unc.edu/~cigar/papers/ManipIHT_June2008(KS).pdf) (finding that attempts to manipulate the Iowa Electronic Markets only affected market prices for brief time periods).

198. *See* Sunstein, *supra* note 4, at 1037 (describing how a coordinated attempt to boost Buchanan share prices on the Iowa Electronic Markets during the 2000 election season resulted in only a transient price spike). During the 2008 election season, unusual bursts in the John McCain share price led some to believe that a manipulator was to blame. *See* David Rothschild & Justin Wolfers, *Market*

ding noise to the system,[199] but this should not significantly affect the market's functionality as long as the FWS considers prices over a range of time.[200]

Manipulation could still permanently alter prices if traders are unable to determine whether anomalous trades are motivated by insider information or deceit.[201] However, the ESA market structure mitigates this problem because parties are required to publicly display their data after placing bets; when interested parties lack the evidence needed to justify quirky bets, the market is instantly tipped off that nefarious motives are at play. Furthermore, the FWS should publicly disclose the origin of all bets, so that repeat traders are able to develop and monitor reputations for reliably acting upon credible information.[202] Finally, manipulative attempts that are successfully detected result in significant transfers of wealth away from the guilty party, so parties should be deterred from attempts even if they possess a small chance of success.

C. Liquidity Constraints and Risk Aversion

Some might contend that most individuals will refrain from participating in the market because of liquidity constraints or risk aversion. This objection is especially noteworthy because it directly challenges my vision of the prediction market as an inclusive institution that assimilates information at the ground level.[203] On the one hand, there are means of participation that require only minimal resources. For example, if a citizen possesses insider informa-

Manipulation Muddies Election Outlook, WSJ.COM, Oct. 2, 2008, http://online.wsj.com/article/SB122283114935193363.html. However, "[o]nce the market dealt with these bumps, the trend immediately reverted to Sen. Obama." *Id.* These occurrences were later confirmed to be manipulative attempts. Josh Rogin, *Trader Drove Up Price of McCain 'Stock' in Online Market*, CQPOLITICS, Oct. 21, 2008, http://www.cqpolitics.com/wmspage.cfm?docID=news-000002976265&referrer=js; *see also* Posting of Alex Tabarrok to http://www.marginalrevolution.com/marginalrevolution/2008/10/manipulation-of.html (Oct. 18, 2008, 7:41 EDT) (arguing attempts at market manipulation support the hypothesis they improve market accuracy).

199. *See supra* note 198.

200. *See supra* note 183 and accompanying text. To counter manipulation, Abramowicz also suggests that the agency wait until trading calms before closing the market, or leave the exact closing time ambiguous. Abramowicz, *supra* note 8, at 974.

201. Abramowicz, *supra* note 8, at 975–76.

202. *Id.* Traders probably would not object to such disclosure, as the ability to develop the reputation of a credible market player is in itself valuable. Without it, traders might be incapable of influencing market prices and thus unable to take gains immediately. *See id.* at 975.

203. *See supra* Part I.

tion, he can place a small bet, disclose that information and collect on the bet after the price moves upward—all within a matter of days, and hence subject to small risk of loss. Yet there are limits to this strategy. Predictions based on enhanced modeling techniques or data that is costly to verify will not be quickly digested by the market; the trader must then possess the security for a longer period, potentially until the market closes.[204] In addition, the size of the insider's gain is constrained by the size of the bet he can afford such that richer individuals will be more incentivized to seek out information. This seems backward from a labor-market efficiency perspective because the wealthy would contend with the highest opportunity costs if they were to spend their days scanning the countryside for endangered species. We also might think of this result as unfair, especially if we view betting on the market as loosely analogous to voting on policy outcomes.[205]

Luckily, individuals can transcend economic constraints by selling information to professional traders. This is a common routine in equity markets, and there is no reason to think the practice would not flourish amidst prediction markets as well.[206] Professional traders, or trading firms, could obtain the financing needed to make large bets (perhaps by tapping the capital markets), and they could reduce risk by dabbling in a range of securities.[207] At first, individuals might be reluctant to sell their secrets for fear of the information being appropriated without payment, as it would be difficult to execute a binding contract before the counterparty knows the nature of the information.[208] However, trading firms might seek to acquire reputations for fair treatment of their "suppli-

204. The more time that passes, the greater the risk that the individual suffers losses due to new information disclosures, so this practice probably is not feasible for most risk-adverse individuals, not to mention those with liquidity constraints.

205. *See* Robin Hanson, *Shall We Vote on Values, Bet on Beliefs?*, 18 J. POL. PHIL. (forthcoming 2010), *available at* http://hanson.gmu.edu/futarchy.pdf (considering a form of government in which policy would be set by speculators betting on which actions they expect to raise national welfare).

206. Abramowicz & Henderson, *supra* note 4, at 1380.

207. The risks associated with most bets are likely to be asset specific rather than systematic, and hence overall risk can be substantially reduced through diversification. In other words, it is unlikely that all of a trader's bets would simultaneously turn sour, a fate that might befall an equity investor during a recession. Burton G. Malkiel, *From A Random Walk Down Wall Street*, *in* FOUNDATIONS OF CORPORATE LAW 26, 34–35 (Roberta Romano ed., 1993).

208. This problem is known as Arrow's Disclosure Paradox. *See* Kenneth J. Arrow, *Economic Welfare and the Allocation of Resources for Invention*, *in* 5 COLLECTED PAPERS OF KENNETH J. ARROW: PRODUCTION AND CAPITAL 104, 111 (1985).

ers" so as to incentivize further information exchange.[209] Alternatively, the citizen could demand a guarantee of a portion of the firm's profits derived from his information prior to disclosing that data.

In some sense, professional traders might be thought of as partnering with the government because they play an especially prominent role in precipitating citizen engagement.[210] In addition to providing liquidity, they can be expected to publicize and facilitate market usage through their active solicitation of information relevant to their bids.[211] For example, if the FWS announces the issuance of a lucrative, highly subsidized new contract, we might expect trading firms to send representatives to the relative area so that they can seek out and interview knowledgeable individuals (for a price). Alternatively, the firm might advertise the existence of a website where individuals could submit pictures of species or development blueprints. The opportunity for profit will surely motivate the firms to experiment with different schemes and implement those that prove successful.

VI.
CONCLUSION

The proposal outlined is ambitious, especially in light of the unproven nature of prediction markets for policy purposes.[212] Certainly there are risks involved; in addition to the concerns already mentioned, prediction markets may prove too complicated for widespread usage, or the financial sums involved may be insufficient to incentivize significant research efforts.

But if prediction markets prove successful, their upside is enormous. Most immediately, endangered species policy would drastically improve because FWS processes would become more transparent and numerous information gaps would be filled. At a broader level, they offer the hope of fundamentally transforming

209. *See* Abramowicz & Henderson, *supra* note 4, at 1380.

210. Professional traders might be loosely analogized to the "service providers" described in *A Constitution of Democratic Experimentalism*. *See* Dorf & Sabel, *supra* note 16, at 317 (describing how service providers leverage their expertise to act as "the link between the government of officials and the local knowledge of citizens").

211. *See* Abramowicz & Henderson, *supra* note 4, at 1380.

212. As far as I know, no federal or state government has made use of prediction markets for policy purposes, save for the Defense Department's ever so brief experiment with the Policy Analysis Market. *See* Hulse, *supra* note 25; Hulse, *supra* note 26.

the agency from an impersonal bureaucracy into a receptor of the labors and knowledge of citizens who are closest to the subject being regulated. Although such a paradigm has already been dreamt up by academics,[213] online markets represent the networking technology that can help bring this vision closer to reality. Surely, prediction markets are somewhat of a gamble, but as any experienced trader can tell you, sometimes gambles pay off.

213. *See supra* note 16 and accompanying text.