The Legal Profession's Critical Role in Systems-Level Bioenergy Decision-Making

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ARTICLE

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I. INTRODUCTION

Scientists construct models as a simplification of reality in order to better understand real-life situations. Policymakers, in turn, use models to make decisions under conditions of great uncertainty and unknowns. Assessment and predictive modeling has been embedded for decades in U.S. environmental law and regulation.[1] The Clean Water Act, Clean Air Act, Safe Drinking Water Act, and many other similar environmental regulations rely on computational models to predict the source, dispersion pattern, and health and environmental risks from pollution.[2] More recently, bioenergy laws have perhaps unknowingly incentivized modeling as a means to determine whether biofuels

1. NAT'L RESEARCH COUNCIL, MODELS IN ENVIRONMENTAL REGULATORY DECISION MAKING 20 (2007).

2. *Council for Regulatory Environmental Modeling*, U.S. EPA, http://www.epa.gov/crem/relatedlinks.html (last visited Mar. 9, 2013); *Renewable Fuels Standard*, U.S. EPA, http://www.epa.gov/otaq/fuels/index.htm (last visited Mar. 9, 2013); Wendy E. Wagner, Elizabeth Fisher, & Pasky Pascual, *Misunderstanding Models in Environmental and Public Health Regulation*, 18 N.Y.U. ENVTL. L.J. 293, 294 (2010).

meet greenhouse gas (GHG) thresholds.[3]   Headline-grabbing claims that modeled results dramatically differ from the underlying intent of these renewable energy policies operate as a call to those within the legal discipline that the design and operation of scientific models can have significant consequences on policy design. Legal scholars only have begun to explore why the legal discipline has been ambivalent at best in engaging more directly with model construction.[4] In addition, scholarship has been relatively inattentive to the *ex post* role that law, as a societal institution, plays as ultimate arbiter of the effects of modeled results.[5]

Legal systems can substantially influence the values and assumptions that form the underlying basis of models, as well as impact their adoption and application. As such, law as a discipline plays an important role in the initial design and operationalization of the model as part of policy implementation, through to judicial processes that provide formal redress from flawed model results. From an *ex ante* perspective, despite economic and life cycle modeling dominating bioenergy policy implementation, law as a discipline has not broadly engaged the regulatory process to ensure the soundness of model structure and inputs.[6] Scientists contend that these models, especially

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3. *Renewable Fuels Standard*, U.S. EPA, http://www.epa.gov/otaq/fuels/index.htm (last visited Mar. 9, 2013); Council Directive 2009/28/EC, 2009 O.J. (L 140) 16, 55 (EC); 17 C.F.R. § 95486 (2012).

4. Elizabeth Fischer, Pasky Pascual, & Wendy Wagner, *Understanding Environmental Models in Their Legal and Regulatory Context*, 22 J. ENVTL. L. 251, 252 (2010).

5. A few exceptions exist on the periphery, however; *see, e.g.*, Matthrew C. Stephenson, *Informational Acquisition and Institutional Design*, 124 HARV. L. REV. 1422, 1427 (2011) (examining "how different institutional arrangements . . . might affect the production of useful information by government agents"); Lynn E. Blais & Wendy E. Wagner, *Emerging Science, Adaptive Regulation, and the Problem of Rulemaking Ruts*, 86 TEX. L. REV. 1701, 1705 (2008) (discussing whether judicial review of agency rulemaking has led to agency ossification).

6. Dan Farber's rich scholarly legacy has been the exception. *See, e.g.*, Daniel A. Farber, *Probabilities Behaving Badly: Complexity Theory and Environmental Uncertainty*, 37 U.C. DAVIS L. REV. 145-73 (Nov. 2003); Daniel A. Farber, *Modeling Climate Change and Its Impacts: Law, Policy, and Science*, 86 TEX. L. REV. 1655-99 (2008); Daniel A. Farber, *Rethinking the Role of Cost-benefit Analysis*, 76 U. CHI. L. REV. 1355, 1355-1405 (2009); Daniel A. Farber, *Indirect Land Use Change, Uncertainty, and Biofuels Policy*, 2011 U. ILL. L. REV. 381 (2011).

ones relied upon in policy decisions, should be tested for validity and verified for accuracy.7 Any conceptual model cannot predict future reality with accuracy (and thus achieve validity), however, without accounting for regulatory and litigatory scenarios that only the legal discipline can assess fully. Legal scholars can extrapolate probable future legal scenarios through an examination of judicial and regulatory trends, which can alter the value of underlying variables.

The assumptions used in modeling indirect land use change (ILUC) demonstrate the critical nature of these legal scenarios. ILUC predicts, among other things, agricultural yields in order to determine how much new agricultural land will be created through conversion.8 Economic models incorporating ILUC add GHGs released from land-use changes, such as converting forests to cropland, to a biofuel's direct emissions derived from biomass production, transportation, and refining. If modeled yield scenarios depend on assumptions regarding genetic modification, modelers must be careful to consider future regulatory landscapes through which genetic modifications must navigate. ILUC models that use historical yield numbers as a proxy for future production may not be portraying future scenarios as accurately as they could be if they considered potential legal developments affecting GM commercialization.

Select American legal scholars have touched generally on potential *ex-ante* procedural solutions to the shortfalls of model use for policy development and implementation.9 Proposed solutions focus on reforming the process of rulemaking through amendments to the Administrative Procedure Act and the Data Quality Act,10 and incorporating adaptive management into agency decision making.11 Once regulatory agencies deploy

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7. Stephen Prisley & Michael Mortimer, *A Synthesis of Literature on Evaluation of Models for Policy Applications, with Implications for Forest Carbon Accounting*, 198 Forest Ecology & Mgmt. 89, 90 (2004).

8. Roman Keeney & Thomas Hertel, *The Indirect Land Use Impacts of U.S. Biofuel Policies: The Importance of Acreage, Yield, and Bilateral Trade Responses* 1-7 (Gtap, Working Paper No. 52, 2008), *available at* https://www.gtap.agecon.purdue.edu/resources/download/4104.pdf.

9. *See generally* Fischer et al., *supra* note 4.

10. Fischer et al., *supra* note 4, at 349-50.

11. *See infra* text and accompanying notes at III.B.2.

modeled results to address environmental problems, however, capacity must be built within judicial institutions to better handle *ex post* the increasingly complex nature of scientific modeling that increasingly finds itself at the center of litigation.[12] In light of calls for policies to be more "science-based," judicial standards of review must balance deference to an agency's technical expertise with society-as-an-institution's acceptance of uncertain model results and accompanying value judgments agencies must make.

Law as a discipline thus must seek greater prominence in the raging debates on the efficacy of modeling as a bioenergy policy driver. To ultimately determine law's proper role, Part II of my article first assesses the universe of key economic and lifecycle models used in current bioenergy policy initiatives, as well as the models deployed in general environmental decision-making that could affect the siting and operation of biomass cropping and bioenergy facilities. Part III then dissects these models to uncover the multiple ways in which law can improve models both structurally and procedurally to achieve greater accuracy. The conclusion speculates that scientific modelers likely have ignored law's valuable place at the table because of the value judgments inherent in policymaking, particularly under scientific uncertainty.

II. BIOENERGY MODELING: A PRIMER

No place in policy implementation is modeling more prevalent than in bioenergy policy today. This is due to statutory requirements that policies reduce GHG emissions from transportation and electricity sectors. Major bioenergy policies such as the U.S. Renewable Fuel Standard (RFS),[13] California Low Carbon Fuel Standard (LCFS),[14] and the European Union's

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12. Fisher et al., *supra* note 4, at 257-62.

13. Energy Independence and Security Act § 202(a)(2), 121 Stat. 1522–24 (codified at 42 U.S.C. § 7545(o)(2)(B) (Supp. II 2009)); RANDY SCHNEPF & BRENT YACOBUCCI, CONG. RESEARCH SERV., RENEWABLE FUEL STANDARD (RFS): OVERVIEW AND ISSUES 2 (2012).

14. Air Res. Bd., Final Regulation Order (Feb. 12, 2011), http://www.arb.ca.gov/fuels/lcfs/CleanFinalRegOrder_02012011.pdf.

Renewable Energy Directive (RED)[15] and Fuel Quality Directive (FQD)[16] set thresholds for minimum GHG reduction that a fuel or feedstock must meet in order to qualify for credit toward renewable energy mandates.   Governments must rely on modeling to predict GHG emissions for a particular fuel. Governments historically also have turned to modeling to measure environmental impacts other than GHG emissions, which may transfer to the bioenergy realm in the near future as environmental consciousness continues to work its way into definitional discussions of what "renewable" energy really should mean.

A. Bioenergy-Specific Modeling

GHG modeling dominates much of bioenergy policy discussions today in the U.S., Europe, and worldwide. Regulators in the U.S. and Europe deploy lifecycle models to measure direct GHG emissions from transportation fuels, and economic models to determine the level of market-mediated indirect emissions resulting from the use of land by various biomass feedstocks used in energy generation (commonly known as indirect land use change, or "ILUC"). In addition to default calculations of direct emissions, the Energy Independence and Security Act of 2007 (EISA) requires the U.S. Environmental Protection Agency (EPA) to calculate ILUC effects for each fuel that seeks to qualify under the RFS mandate.[17] Both EPA and the California Air Resources Board (ARB) have chosen to use a form of the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model—a "lifecycle analysis" or "LCA" model—to estimate direct lifecycle GHG emissions.[18]   For ILUC

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15. Council Directive 2009/28/EC, 2009 O.J. (L 140) 16, 16-18 (EC) [hereinafter RED].

16. Council Directive 2009/30/EC, 2009 O.J. (L 140) 88, 88-89 (EC) [hereinafter FQA].

17. *See generally* Energy Independence and Security Act of 2007 § 202(a), Pub. L. No. 110-140, 121 Stat. 1492, (codified at 42 U.S.C. § 7545(o)(1)(H)).

18. Regulation of Fuels and Fuel Additives: Renewable Fuel Standard Program, 72 Fed. Reg. 23900, 23907 (May 1, 2007) (codified at 40 C.F.R. pt. 80); *see also Low Carbon Fuel Standard Program Background*, CAL. AIR RES. BD., http://www.arb.ca.gov/fuels/lcfs/lcfs-background.htm (last visited Mar. 9, 2013).

calculations, EPA selected the Forest and Agricultural Sector Optimization Model (FASOM) for domestic ILUC[19] and the Food and Agricultural Policy Research Institute (FAPRI) model for determining the GHG emissions from international ILUC.[20] ARB, on the other hand, uses the Global Trade Analysis (GTAP) model for ILUC calculations,[21] and allows regulated parties to submit customized calculations through its "Method 2A/2B" application.[22] Unlike lifecycle analysis, these models depend on economic analysis of "shocks" within the market system.

The EU RED Annex V sets default values and a calculation methodology for direct GHG emissions from various biofuels.[23] The Commission derived the default values with input from the JEC consortium,[24] which consists of the Joint Research Centre of the European Commission (JRC), European Council for Automotive R & D (EUCAR), and the Research Association of the European Oil Refining Industry (CONCAWE).[25] The Commission added clarification of its methodology in calculating land carbon stocks in 2010.[26]

While the RED does not specify the standard values or input numbers it used in arriving at its default direct emission values, the Biograce project has incorporated values and input numbers in a harmonized calculation tool that users can further customize to fit their operations.[27] In an attempt to reconcile the RED with the increasing scientific consensus on the detrimental effects of

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19. U.S. EPA, RENEWABLE FUEL STANDARD PROGRAM (RFS2) REGULATORY IMPACT ANALYSIS, EPA-420-R-10-006, 316-18 (2010) [hereinafter RIA].

20. *Id.*

21. *See Low Carbon Fuel Standard Program Background*, CAL. AIR RES. BD., http://www.arb.ca.gov/fuels/lcfs/lcfs-background.htm (last visited Mar. 9, 2013).

22. 17 C.F.R. § 95486 (2012).

23. Council Directive 2009/28/EC, *supra* note 3, at 52-59.

24. *See* JOINT RESEARCH CTR., SUSTAINABILITY OF BIOENERGY: INPUT DATA RELEVANT TO CALCULATING DEFAULT GHG EMISSIONS FROM BIOFUELS ACCORDING TO RE DIRECTIVE METHODOLOGY (2012), *available at* http://re.jrc.ec.europa.eu/biof/html/input_data_ghg.htm.

25. *Downloads*, JOINT RESEARCH CTR., INST. FOR ENERGY AND TRANSP., http://iet.jrc.ec.europa.eu/about-jec/downloads (last visited Mar. 9, 2013).

26. Council Communication 2010/C of 19 June 2010, 2010 O.J. (C 160) 8.

27. *Harmonized Calculations of Biofuel Greenhouse Gas Emissions in Europe*, BIOGRACE, http://www.biograce.net/content/aboutthebiograceproject/background (last visited Mar. 9, 2013).

ILUC, the Commission conducted further research in order to find the most appropriate method of minimizing ILUC effects.[28] The Commission requested that the JRC and International Food Policy Institute (IFPRI) provide information to better assess ILUC impacts of the RED, and a number of studies were issued analyzing ILUC impacts of RED mandates through economic models including AGLINK-COSIMO, Modeling International Relationships in Applied General Equilibrium (MIRAGE), European Simulation Model (ESIM), and Common Agricultural Policy Regionalized Impact (CAPRI).[29]   Their conclusions have resulted in the Commission formally proposing regulation of ILUC with respect to biofuels that qualify for the RED.[30]

While law scholars and practitioners rarely engage at the frontiers of modeling activities, their growing predominance in critically important policy decisions demonstrates that this can no longer be the case.   The following sections provide an important prerequisite to understanding and remedying their internal weaknesses with regard to predictive scenarios based in part on policy assumptions.

a. Lifecycle Analysis (LCA)

LCA has the potential to greatly influence policy outcomes. LCA calculates any type of environmental, social, or economic footprint throughout a biofuel's production chain. This "cradle to the grave" analysis measures impacts from biomass production, transportation of raw material, refining and manufacturing processes, co-product generation, distribution, and consumer end-

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28. Council Directive 2009/28/EC, *supra* note 3, at 25.

29. ROBERT EDWARDS ET AL., JOINT RESEARCH CTR., INDIRECT LAND USE FROM INCREASED BIOFUELS DEMAND 6 (2010); MARIA FONSECA ET AL., JOINT RESEARCH CTR., IMPACTS OF THE EU BIOFUEL TARGET ON AGRICULTURAL MARKETS AND LAND USE: A COMPARATIVE MODELING ASSESSMENT 9-11 (2010); ROLAND HIEDERER ET AL., JOINT RESEARCH CTR., BIOFUELS: A NEW METHODOLOGY TO ESTIMATE GHG EMISSIONS FROM GLOBAL LAND USE CHANGE 3-5 (2010); DAVID LABORDE, IFPRI, ASSESSING THE LAND USE CHANGE CONSEQUENCES OF EUROPEAN BIOFUEL POLICIES 9-10 (2011).

30. *See Commission Proposal for a Directive of the European Parliament and the Council Amending Directive 90/70/EC Relating to the Quality of Petrol and Diesel Fuels and Amending Directive 2009/28/EC on the Promotion of the Use of Energy from Renewable Sources*, COM (2012) 595 final (Oct. 17, 2012).

use.[31]   While results of LCA can vary widely, framework methodologies have achieved a level of worldwide consensus.[32]

The LCA process is divided into four phases: goal and scope definition, inventory analysis, impact assessment, and interpretation.[33]   Goal and scope definition isolates the exact purpose and outputs of the study, system boundaries, the functional unit to which data are normalized, and assumptions.[34] Drawing a system boundary has great importance because it captures all activities within the boundary that contribute to the unit of impact measured. It is at this phase that the modeler must determine whether to use "attributional" or "consequential" LCA.   Attributional models, such as GREET, only seek to measure the direct effects of a production process by examining inputs (energy, raw materials, etc.) and outputs (GHG emissions, waste by-products) throughout the production process and allocating impacts among the various products of the process.[35]

Consequential models, on the other hand, consider both direct and indirect effects of the production process.[36] While such models still consider the inputs and outputs of every stage of the production process, the analysis is expanded to include chains of causal relationships.[37] For example, a consequential model may consider the effects that introduction of a product will have on its complementary products, substitutes, and the market in general.[38]   Consequential models attempt to discern, to a

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31. *See* INT'L STANDARD ORG., ENVIRONMENTAL MANAGEMENT – LIFE CYCLE ASSESSMENT – PRINCIPLES AND FRAMEWORK 6-7 (2d ed. 2006) [hereinafter ISO LCA PRINCIPLES]; Robert Ayres, *Life Cycle Analysis: A Critique*, 14 RES. CONSERVATION RECYCLING 199, 199-200 (1995).

32. ISO LCA PRINCIPLES, *supra* note 31, at IV-V.

33. *Id.* at V.

34. *Id.* at 11.

35. Carly Whittaker et al., *Greenhouse Gas Reporting for Biofuels: A Comparison Between the RED, RTFO and PAS2050 Methodologies*, 39 ENERGY POL'Y 5950, 5950-60 (2011).

36. *Id.* at 5954.

37. Michael Wang et al., *Methods of Dealing with Co-products of Biofuels in Life-Cycle Analysis and Consequent Results within the U.S. Context*, 39 ENERGY POL'Y 5726, 5727 (2011).

38. Tomas Ekvall & Bo Weidema, *System Boundaries and Input Data in Consequential Life Cycle Inventory Analysis*, 9 INT. J. LIFE CYCLE ASSESSMENT 161, 162-64 (2004).

reasonable degree, all of the causal relationships associated with the production of a material and attribute these effects to the product under scrutiny.[39]   When a process produces more than one output, LCA practitioners use allocation based on denominators such as weight, energy content, volume, or costs of the products, or system expansion.   System expansion (or alternatively, "displacement") in consequential LCA calculates the impact of any co-product based on its replacement value in the world market.[40]   For example, dried distillers grains (DDGs) from the corn ethanol process replace other types of feed that would otherwise be fed to cattle.[41]   Thus, a GHG credit is given for DDG production by the ethanol facility because the need for land to produce feed is reduced.[42]   While the International Organization for Standardization (ISO) 14040 standard favors system expansion, the EU RED utilizes the allocation method.[43]

Upon completion of the scoping phase, the inventory phase seeks to collect relevant data on all inputs and outputs, typically drawn from databases.[44]   Data quality is critical to accurate LCA outcomes.[45]   Aggregated or generalized data may pose a problem when attempting to demonstrate individualized causality.[46]   For example, the GREET model uses various forms of default data, although its spreadsheet allows for customization of data if available.[47]   Problems also arise with the age of data, geographic representativeness, technological representativeness, and sources of data.[48]   Third-party review of data sets becomes difficult, if not

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39. *Id.* at 170.

40. Wang et al., *supra* note 37, at 5728.

41. *Id.*

42. *Id.*

43. *Id.*

44. ISO LCA PRINCIPLES, *supra* note 31, at 13.

45. *Id.*

46. Martin Elff et al., *Ignoramus, Ignorabimus? On Uncertainty in Ecological Inference*, 16 POL. ANALYSIS 70, 71 (2008); GARY KING, A SOLUTION TO THE ECOLOGICAL INFERENCE PROBLEM: RECONSTRUCTING INDIVIDUAL BEHAVIOR FROM AGGREGATE DATA XV (1997).

47. MICHAEL WANG ET AL., ARGONNE NAT'L LAB., OPERATING MANUAL FOR GREET: VERSION 1.7 (2007).

48. Eric Peereboom et al., *Influence of Inventory Data Sets on Life-Cycle Assessment Results: A Case Study on PVC*, 2 J. INDUS. ECOLOGY 109, 111-12 (1998).

impossible, when data sets are proprietary and thus off-limits to detailed review, or are prohibitively expensive for an entity to purchase access. In the end, model outputs are only as good as data inputs,[49] yet data availability and quality continue to be critical problems that plague all four phases.[50]

Once the inventory is complete, impact analysis translates the data gathered in the inventory analysis by understanding and evaluating impacts within the goals and scope set by the study's stakeholders.[51] This analysis includes classification, characterization, normalization, and valuation of impacts.[52] Valuation weights the importance of impacts in order for them to be compared or aggregated.[53] Time horizons are an important element in LCA impact analysis of GHG emissions.[54] Most studies estimating land use change emissions from biofuels use straight-line amortization, assigning each crop generation an equal share of GHG emissions over a certain timeframe.[55] This method can lead to results that significantly underestimate the effect land use change (LUC) has on GHG emissions.[56] One study estimates that using straight-line amortization can lead to results that underestimate the effect of these emissions on climate change by up to eighty-percent.[57] Alternative approaches, however, require assumptions regarding the level of discount that should be assigned to future emissions that presumably are less

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49. John Reap et al., *A Survey of Unresolved Problems in Life Cycle Assessment Part 2: Impact Assessment and Interpretation*, 13 INT'L J. LIFE CYCLE ASSESSMENT 374, 374 (2008); *see also* Peereboom et al., *supra* note 48, at 127-28; Bea De Smet & Mark Stalmans, *LCI Data and Data Quality: Thoughts and Considerations*, 1 INT. J. LIFE CYCLE ASSESSMENT 96 (1996).

50. Reap et al., *supra* note 49, at 374.

51. ISO LCA PRINCIPLES, *supra* note 31, at 18.

52. *Id.*; Poritosh Roy et al., *A Review of Life Cycle Assessment (LCA) on Some Food Products*, 90 J. FOOD ENG'G 1, 3 (2009).

53. Roy et al., *supra* note 52.

54. Alissa Kendall et al., *Accounting for Time-Dependent Effects in Biofuel Life Cycle Greenhouse Gas Emissions Calculations*, 43 ENVTL. SCI. TECH. 7142, 7142 (2009).

55. *Id.*

56. *Id.*

57. *Id.*

harmful than those occurring before a climatic "tipping point," thus adding increased uncertainty.[58]

The last phase of LCA—interpretation—evaluates assumptions, judges choices made, analyzes results, and formulates the conclusions and recommendations of the study.[59] While undervalued in the literature, this phase can be particularly critical to the extent it contributes to the legal discipline's ability to translate and evaluate LCA results. This type of analysis lends itself especially well to the type of legal contribution I advocate throughout this article.

Despite this standard methodological framework, interpretation of LCA results, particularly LCAs concerning biofuels, can lead to several forms of uncertainty.[60] Model documentation often does not reveal sources of uncertainty in a transparent manner, thus feeding controversy that inevitably results from regulatory decisions based on wide probability distributions. Policymakers and the public thus should be made aware that complete sets of data may not be available, are of poor quality, or are extrapolated from a model versus real-time system. Likewise, decision-makers must examine a LCA's scope and consider whether it is broad enough to adequately demonstrate causation. Cognizance of these and other LCA aspects is essential to accurate interpretation of LCA studies because, despite the appearance of objectivity in its "scientific" label, value judgments are applied throughout the LCA methodological framework.[61]

b. Economic Models

Compared to the GREET model, which is a LCA model, the FASOM, FAPRI, and GTAP models used in predicting the GHG

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58. Madhu Khanna et al., *Can Biofuels be a Solution to Climate Change? The Implications of Land Use Change-Related Emissions for Policy*, 1 INTERFACE FOCUS 233, 241 (2011).

59. JEROEN GUINEE, HANDBOOK ON LIFE CYCLE ASSESSMENT: OPERATIONAL GUIDE TO THE ISO STANDARDS 97-98 (2002).

60. Felix Creutzig et al., *Reconciling Top-Down and Bottom-Up Modelling on Future Bioenergy Deployment*, 2 NATURE CLIMATE CHANGE 320, 320 (2012); *see* Reap et al., *supra* note 49, at 374.

61. Creutzig et al., *supra* note 60, at 323-25.

effects of U.S. bioenergy policy, and the various economic models that guide the EU RED, fall into the category of economic models. These economic models can be further divided into computable general equilibrium (CGE) models and partial equilibrium (PE) models.[62] Kretschmer & Peterson and a peer review of models used for the U.S. RFS discuss in detail the advantages and disadvantages of each model type with regard to bioenergy analyses.[63] The most important differences between the models, from the perspective of the legal discipline's role in improving bioenergy model construction and implementation, lie in their treatment of land use. Models address land use both directly and indirectly through a number of variables including land cover types, land rents, yield rates, management practices, technological improvement (e.g., use of fertilizer), and measures of biodiversity.[64] Whether and how land is used for biomass versus food cropping lies at the center of controversies surrounding the inclusion of market-mediated ILUC in GHG emissions calculations.[65] Economic models are evolving to link measurements of market-mediated land-use change with ecosystem process models as focus grows on other environmental impacts such as water quality and biodiversity.[66] While PE models "allow for a detailed representation of agricultural and bioenergy production and land use restrictions," and "are able to simulate detailed policy proposals," they do not account for the market for land in great detail.[67] Further, PE models "lack . . . adequate coverage of the linkages between agri-food markets and the general economy," as well as "possible links to other political .

62. Bettina Kretschmer & Sonja Peterson, *Integrating Bioenergy into Computable General Equilibrium Models—A Survey*, 32 ENERGY ECON. 673, 673-674 (2010).

63. *Id.* at 674-75; ICF INT'L, LIFECYCLE GREENHOUSE GAS EMISSIONS DUE TO INCREASED BIOFUEL PRODUCTION: MODEL LINKAGE PEER REVIEW REPORT (2009), *available at* http://epa.gov/oms/renewablefuels/rfs2-peer-review-model.pdf [hereinafter IFC PEER REVIEW REPORT].

64. Timothy Searchinger et al., *Use of U.S. Croplands for Biofuels Increases Greenhouse Gases through Emissions from Land-Use Change*, 39 SCI. 1238, 1238-40 (2008); Kretschmer & Peterson, *supra* note 62, at 682.

65. Kretschmer & Peterson, *supra* note 62, at 674.

66. Creutzig et al., *supra* note 60, at 320-22; Kretschmer & Peterson, *supra* note 62, at 685.

67. Kretschmer & Peterson, *supra* note 62, at 675.

. . issues."68 CGE models like GTAP, on the other hand, are able to explicitly model the land market in much more detail,69 but in return sacrifice transparency because of the complexity resulting from their factoring in all sectors of a specific economy.70

Economic equilibrium models have been criticized as too narrow to capture the system dynamics affecting land use.71 Others have proposed integrating LCA into agent-based modeling to better facilitate decision-making based on information about environmental impacts within a bioenergy infrastructure while it develops.72

One economic model, Policy Analysis System (POLYSYS), has been used by both the U.S. Department of Energy (DOE) and the U.S. Department of Agriculture (USDA) to inform bioenergy policy choices from a systemic view of the U.S. agricultural sector.73 POLYSYS provides a modular modeling framework for evaluating the impacts of economic, policy, or environmental changes.74   The framework uses a variety of models and databases from econometric, linear programming, and process models, organized around crop supply, crop demand, livestock supply and demand, and agricultural income.75 For example, the model uses a regional crop rotations module, in conjunction with

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68. ICF PEER REVIEW REPORT, *supra* note 63, at I-6.

69. Kretschmer & Peterson, *supra* note 62, at 675-76.

70. IAN WING, MIT JOINT PROGRAM ON THE SCI. & POLICY OF GLOBAL CHANGE, COMPUTABLE GENERAL EQUILIBRIUM MODELS AND THEIR USE IN ECONOMY – WIDE POLICY ANALYSIS: EVERYTHING YOU EVER WANTED TO KNOW (BUT WERE AFRAID TO ASK)   2   (2004),   *available   at*   http://web.mit.edu/ globalchange/www/MITJPSPGC_TechNote6.pdf.

71. ICF PEER REVIEW REPORT, *supra* note 63, at 6.

72. *See* Chris Davis et al., *Integration of Life Cycle Assessment into Agent-Based Modeling: Toward Informed Decisions on Evolving Infrastructure Systems*, 13 J. INDUS. ECOLOGY 306, 306 (2009).

73. U.S. DEP'T OF ENERGY, U.S. BILLION-TON UPDATE: BIOMASS SUPPLY FOR A BIOENERGY AND BIOPRODUCTS INDUSTRY 87 (2011), *available at* http://www1.eere.energy.gov/biomass/pdfs/billion_ton_update.pdf [hereinafter UPDATED BILLION TON STUDY]; U.S. DEP'T OF AGRIC., BIOMASS CROP ASSISTANCE PROGRAM: PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT (2010) [hereinafter BCAP PEIS].

74. Daniel De La Torre Ugarte & Daryll E. Ray, *Biomass and Bioenergy Applications of POLYSYS Modeling Framework*, 18 BIOMASS & BIOENERGY 291, 291 (2000).

75. *Id.* at 292.

the Environmental Policy Integrated Climate (EPIC) model, to estimate environmental impacts such as "yields, soil erosion, chemical runoff and leaching, nutrient availability, organic carbon, soil structure and pH values, water-holding capacity, pesticide indicators, and other environmental variables for each soil and crop combination for each region."[76] These outcomes may be influenced by regulatory decisions, such as those affecting the viability of new strains of genetically modified crops or limits on nutrient loading within watersheds. For this type of estimation, POLYSYS relies on data such as the USDA's Cropping Practices Survey.[77] The model also can estimate community impacts through interactions with the IMPLAN model.[78] DOE's 2011 Billion Ton Update relied on POLYSYS to estimate the availability of biomass, including how much crop and pasture land may shift to energy crops.[79] USDA utilized POLYSYS to evaluate the programmatic impacts of the Biomass Crop Assistance Program (BCAP), a government subsidy program for energy biomass.[80] Thus, POLYSYS has the potential to steer both short- and long-term decisions on biofuels industry investment and other strategies beyond merely measuring GHG effects.

Aside from GHG and ILUC accounting, one of the most controversial aspects of biomass-to-bioenergy policy—the "food versus fuel" debate—has been informed greatly by economic models. The broad range of viewpoints and polarization present in the public debate surrounding biofuels mirrors the variation of modeling outcomes. Both general and partial equilibrium models attempt to measure biofuels' impact on food prices by utilizing various price indicators (e.g., global food index[81] and U.S. food

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76. *Id.* at 296.

77. *Id.* at 298.

78. *Id.* at 297.

79. UPDATED BILLION TON STUDY, *supra* note 73, at 87.

80. BCAP PEIS, *supra* note 73, at 4-2, 4-3.

81. Rafael De Hoyos & Denis Medvedev, *Poverty Effects of Higher Food Prices: A Global Perspective* (World Bank Policy Research, Working Paper No. 4887, 2009).

prices),82 but come to diverse conclusions.83 Models use scenarios to measure the impact of various government policies on food price inflation, including RFS2 mandates, excise tax incentives, repeal of all government biofuel incentives,84 and the release of Conservation Reserve Program (CRP) land.85 Some models go beyond price forecasting to measuring biofuels' contribution to poverty rates,86 caloric intake, and malnutrition levels.87 Variability in model outputs ultimately results from differences in forecasting models employed, price measures utilized, time periods evaluated, and analysts' perspectives.88

GTAP-BYP and the Modeling International Relationships in Applied General Equilibrium (MIRAGE) are prominent examples of CGE models that analyze biofuel's effect on food security. MIRAGE is a multi-country, multi-sector, dynamic model that was initially developed to study trade policy but is adaptable to other scenarios such as fuel-food effects.89 MIRAGE's primary source of information is the GTAP7 Database, which covers 113 regions of the world and 57 sectors.90 Modelers must significantly modify MIRAGE to analyze the complex relationship

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82. SIMLA TOKGOZ ET AL., 07-SR, CTR. FOR AGRIC. & RURAL DEV., EMERGING BIOFUELS: OUTLOOK OF EFFECTS ON U.S. GRAIN, OILSEED, AND LIVESTOCK MARKETS 101 (2007).

83. *See, e.g.,* Gal Hochman et al., *The Role of Inventory Adjustments in Quantifying Factors Causing Food Price Inflation* (The World Bank Policy Research, Working Paper No. 5744, 2011) (estimating biofuels resulted in a 9.8% increase in corn prices); Siwa Msangi et al., *Global Scenarios for Biofuels: Impacts and Implications for Food Security and Water Use*, IFPRI Paper Presented at the Tenth Annual Conference on Global Economic Analysis special session on "CGE Modeling of Climate, Land Use, and Water: Challenges and Applications" (2007) (estimating biofuels resulted in up to a 41% increase in corn prices).

84. Xiaoguang Chen & Madhu Khanna, *Food vs. Fuel: The Effect of Biofuel Policies*, AMER. J. AGRI. ECON. 285 (May 2011).

85. TOKGOZ ET AL., *supra* note 82.

86. Hoyos & Medvedev, *supra* note 81.

87. Msangi et al., *supra* note 83, at 7.

88. Sherry Mueller et al., *Impact of Biofuel Production and other Supply and Demand Factors on Food Price Increases in 2008*, 35 BIOMASS & BIOENERGY 1623, 1630 (2011).

89. *The MIRAGE Model*, IFPRI, http://www.ifpri.org/book-5076/ourwork/program/mirage-model (last visited Mar. 9, 2013).

90. *Id.*

between the biofuels and energy sectors,[91] as varying degrees of substitutability exist between sources of energy.[92] Six additional sectors were introduced into the GTAP7 Database in order to better represent the complexity of the biofuels market, including ethanol, biodiesel, transportation, corn, oilseeds, and fertilizers.[93] One study utilizing this modified version of MIRAGE estimated an 11.2% increase in world corn prices and 2.7% increase in wheat prices due to biofuel-induced feedstock demand.[94]

GTAP-BYP, on the other hand, allows substitution between biofuels and petroleum products[95] and is one of the first general equilibrium models to explicitly address the effect of DDGs on feedstock demand and land use change.[96] This allows the model to assume that as biofuel production is incentivized, the volume of byproducts also increases and results in its downward price pressure, encouraging increased DDGs use in the livestock industry. In turn, DDGs use eases demand for corn and soybean meal within the livestock industry, mitigating the land use consequences of biofuel production. Application of this modeling framework demonstrates that exclusion of byproducts can lead to overestimation of biofuel-induced impacts on food price inflation.[97]

AGLINK-COSIMO, IMPACT, and FAPRI are the PE counterparts of GTAP and MIRAGE. PE models only consider selective parts of the economy (i.e. energy or transportation sectors) and thus are not capable of capturing the feedback effects that shocks create among sectors.[98] PE models may pair with other PE models, however, in order to achieve these interactions. One study seeking to gauge causality between biofuels mandates

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91. Antoine Bouet et al., *Modeling the Global Trade and Environmental Impacts of Biofuel Policies* 2 (Int'l Food Policy Research Inst., Discussion Paper No. 01018, 2010).

92. *Id.*

93. *Id.*

94. *Id.* at 21.

95. Farzad Taheripour et al., *Biofuels and their By-Products: Global Economic and Environmental Implications*, 34 BIOMASS & BIOENERGY 278, 279 (2010).

96. *Id.*

97. *Id.*

98. Bouet et al., *supra* note 91, at 1.

and rising food prices paired the Organization for Economic Co-operation and Development's (OECD) partial equilibrium agricultural model, AGLINK, with the Food and Agricultural Organization's (FAO) agricultural model, COSIMO, and the OECD World Sugar Model.[99] Together, these models attempt to represent the relationship between oil prices, biofuel production, their impacts on crop and livestock production costs, and ultimately effects on food price inflation. The study considered three scenarios: no biofuel growth, biofuel growth along publicly stated goals, and a high oil price scenario.[100] Sustained high oil prices directly led to increases in agricultural production costs, which reduces production and results in higher agricultural commodity prices. High oil prices also indirectly increase the demand for petroleum substitutes—biofuels—which also results in higher commodity prices. The study found that the combined effect of a high oil price scenario could increase world sugar prices by up to 60% and vegetable oil prices by up to 15% in 2014.[101]

FAPRI and IFPRI's IMPACT models, two other major partial equilibrium models, have been utilized to predict food price effects of biofuels policies through scenario building. IFPRI deploys IMPACT in conjunction with three scenarios (a conventional fuels scenario, second generation biofuels scenario (e.g., fuels from perennial crops), and second generation biofuel with aggressive productivity growth) to investigate the claim that second generation biofuels may have a lesser impact on food price inflation.[102] One study highlights how, if this model assumes increased investment in next generation biofuel production facilities and crop technology, agricultural commodity prices are decreased.[103] The study, however, does not explicitly address land scarcity and therefore may be overestimating the mitigating effects of second generation biofuels because, even though they eliminate directly the consumption of food crops for fuels, they

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99. ORG. FOR ECON. CO-OPERATION AND DEV., AGR/CA/APM(2005)24/FINAL, AGRICULTURAL MARKET IMPACTS OF FUTURE GROWTH IN THE PRODUCTION OF BIOFUELS (Feb. 1, 2006).

100. *Id.* at 24-27.

101. *Id.* at 26.

102. Msangi et al., *supra* note 83, at 7-9.

103. *Id.* at 7-8.

still compete with food cropping for a finite amount of land. Another study employed the FAPRI model to analyze deficiencies in ethanol distribution infrastructure in relation to demand responses and ultimately price levels.[104] The study exposed that models should not unrealistically assume that distribution bottlenecks will be resolved. Otherwise, models inflate ethanol demand projections, and thus correspondingly inflate commodity price projections.[105]

B. Generic Environmental and Other Models

In addition to efforts aimed at modeling specifically biofuels' impacts, other types of models[106] that measure environmental impacts have the capacity to greatly influence biofuels policy. For example, in 2009 an international consortium concluded that, based on GLOBIO3, IMAGE 2.4, and EUROMOVE modeling and various databases,[107] a climate mitigation scenario that includes extensive use of bioenergy will result in dramatic loss of net mean species abundance (MSA).[108] The EU Joint Research Centre similarly has estimated impacts on biodiversity applying their own methodology to IFPRI outputs and utilizing GLOBIO3 mean species abundance values.[109] JRC concluded preliminarily that land use change predicted in the IFPRI economic model may

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104. Dermot Hayes et al., *Biofuels: Potential Production Capacity, Effects on Grain and Livestock Sectors, and Implications for Food Price and Consumers*, 41 J. AGRI. & APPLIED ECON. 465 (2009).

105. *Id* at 471.

106. Many assessment tools exist. *See, e.g.*, Christine Dragisic et al., *Tools and methodologies to support more sustainable biofuel feedstock production*, 38 J. INDUS. MICROBIOLOGY & BIOTECH. 371, 371-74 (2011) (applying the Integrated Biodiversity Assessment Tool (IBAT), the ARtiWcial Intelligence for Ecosystem Services (ARIES) tool, the Responsible Cultivation Areas (RCA) methodology, and the Biofuels + Forest Carbon (*Biofuel + FC*) methodology). A survey of the entire generic universe of ecosystems modeling is beyond the scope of this paper, however.

107. Rob Alkemade et al., *GLOBIO3: A Framework to Investigate Options for Reducing Global Terrestrial Biodiversity Loss*, 12 J. ECOSYSTEMS 374, 377 (2009).

108. *Id.* at 387-88.

109. LUISA MARELLI ET AL., JOINT RESEARCH CTR., ESTIMATE OF GHG EMISSIONS FROM GLOBAL LAND USE CHANGE SCENARIOS 31 (2011).

decrease MSA by 85% on converted land.[110] Although not tied to economic modeling of the RFS, scientists have concluded through quantitative meta-analysis that similar effects could occur in the U.S.[111]

In addition to GHGs and biodiversity, water quality and quantity concerns associated with biofuels will likely dominate policy discussions into the future. In the Chesapeake Bay Watershed, EPA has employed modeling to determine sources of nutrient loading and assign responsibilities for management planning within various states in the shed.[112] The Chesapeake Bay Phase 5.3 Watershed Model (Watershed) simulates the conditions of the Bay environment by taking a wide variety of factors into account such as precipitation, land use, sediment, land and river segmentation, and best management practices, among others.[113] Watershed divides the Bay into approximately 1,000 different segments consisting of a variety of land types such as cropland, woodland, pasture, urban lands, and other special land uses.[114]   Watershed uses Scenario Builder (Builder) to estimate the amount of nutrients that are expected to reach the Bay from non-point sources such as agriculture.[115] Examples of inputs Builder uses to determine nutrient loading include manure generation, fertilizer application, septic system loads, maximum crop uptake, and many others.[116] Watershed and Builder are linked to the Airshed model, which calculates atmospheric deposition of nitrogen to land and waters.[117]

Watershed's load calculations drastically differ from those generated by a similar USDA model, leading to increased scrutiny of the assumptions underlying Watershed.[118] USDA's

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110. *Id.* at 32.

111. Robert Fletcher et al., *Biodiversity Conservation in the Era of Biofuels: Risks and Opportunities*, 9 FRONTIERS IN ECOLOGY & ENV'T 161, 166-67 (2011).

112. U.S. EPA, CHESAPEAKE BAY PHASE 5.3 COMMUNITY WATERSHED MODEL SECTION 1 (OVERVIEW) 1-7 (2010).

113. *Id.*

114. *Id.* at 1-17.

115. *Id.* at 1-14.

116. *Id.* at 1-7.

117. *Id.* at 1-21.

118. LIMNOTECH, AN UPDATED COMPARISON OF LOAD ESTIMATES FOR CULTIVATED CROPLAND IN THE CHESAPEAKE BAY WATERSHED 1 (2011).

modeling approach consists of multiple components including: the National Resources Inventory Soil Survey (statistical sample representing the diversity of soils and other conditions in the Bay region); NRI-CEAP Cropland Survey (farmer survey of conservation practices currently in use); Agricultural Policy Environmental Extender (APEX) (a field-scale physical process model used to determine the physical effects of conversion practices); Hydrologic Unit Model for the United States (a watershed model and system of databases); and the Soil and Water Assessment Tool (SWAT) (model used to simulate non-point source loadings from land uses other than cropland).[119] Discrepancies between the two models lie in part with their underlying assumptions, including the number of acres used for growing crops, total agricultural land, land-management practices, nitrogen runoff from cropland, nitrogen runoff reaching the Bay, and many others.[120] Further, both models are data intensive, but use different data sets for model inputs.[121] The stark differences make the two models difficult to compare.

III. THE BENEFICIAL ROLES OF THE LEGAL DISCIPLINE IN THE MODELING PROCESS

The legal profession potentially can improve in three key ways the use of lifecycle, economic, and other models in bioenergy policymaking. Within models, legal perspectives can contribute to more accurate calculations of present and future realities if incorporated in model scenarios and assumptions. Law as an institution (actors and formal rules) also can ensure that its rule-making processes provide adequate transparency for model scrutiny *ex ante*, and provide competent *ex post* adjudication when modeling disputes arise.

A. Structural Contributions

Not unlike natural systems, legal systems exhibit similar complexity. Multiple layers of rules apply, administered by

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119. *Id.* at 7-9.
120. *Id.* at 3-19
121. *Id.* at 2.

numerous agencies, within a patchwork of various political jurisdictions that do not always neatly coincide with ecological or economic system boundaries. The legal system influences many of the variables and values contained in lifecycle and economic models. Legal scholars are uniquely trained to analyze trends in legislation, regulation, and litigation, which combine to form a complex web of potential scenarios and outcomes. Lawyers have increasingly grown accustomed to analysis of empirical data in its broadest sense, encompassing world experience and observation of both qualitative and quantitative data, but have struggled with developing proper methodologies.[122] While law as a discipline continues to internally grapple with its own ability to make proper empirical inferences,[123] modelers who ignore the valuable contribution of law in explaining current and predicting future policy scenarios oversimplify the reality they seek to measure. The following examples are meant to demonstrate the effects of this oversight.

a. Yield-Based Land Use Estimations

Economic models use yield as one variable in predicting land use change. The models base assumptions regarding crop yields on historical rates of increase.[124] Emerging technologies, however, can profoundly change assumptions underlying LCA.[125] ARB has recognized that projected changes in agricultural practices, such as the use of genetically modified seed, "should be included as confidence in the robustness of projections permits."[126] Likewise, in projecting future crop yields, EPA does not take into account the possibility that crop yields might

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122. Lee Epstein & Gary King, *The Rules of Inference*, 69 U. CHI. L. REV. 1, 2-9 (2002).

123. *Id.* at 6-10.

124. Roman Keeney & Thomas Hertel, *The Indirect Land Use Impacts of U.S. Biofuel Policies: The Importance of Acreage, Yield, and Bilateral Trade Responses* 9 (GTAP, Working Paper No. 52, 2008), *available at* https://www.gtap.agecon.purdue.edu/resources/download/4104.pdf.

125. Thomas McKone et al., *Grand Challenges for Life-Cycle Assessment of Biofuels*, 45 ENV'T SCI. & TECH. 1751, 1755-56 (2011).

126. CAL. AIR RES. BD., FINAL REPORT OF THE CARB EXPERT SUBGROUP ON "COMPARATIVE AND ALTERNATIVE MODELING APPROACHES" (2010), *available at* http://www.arb.ca.gov/lcfs/workgroups/ewg/010511-final-rpt-indirect-effects.pdf.

increase at an accelerated rate due to genetic modification biotechnology.[127] None of the economic models used in the RFS or LCFS—GTAP, FAPRI, or FASOM—factor the possibility of increased yields from biotechnology, or other effects of biotechnology such as input use.

To the extent scientists engineer a new generation of biotech energy crops, regulatory and litigation outcomes can be analyzed to estimate the probability of the speed at which technology can be legally commercialized. Historical yields of traditional commodity crops planted with biotech seed are based on a policy paradigm mired in regulatory hurdles, and at times, litigation.[128] For example, Monsanto has fought for almost six years in order to deregulate and bring its Roundup Ready™ (RR) alfalfa to market.[129] Litigation has centered on USDA's Animal and Plant Inspection Service's (APHIS) failure to prepare an environmental impact statement (EIS) under the National Environmental Policy Act (NEPA).[130] The U.S. Supreme Court held that the District Court abused its discretion when it enjoined APHIS from partially deregulating RRA pending the agency's completion of a detailed environmental review.[131] APHIS completed the review and issued the environmental impact statement in late 2010.[132] Based on the EIS's findings, USDA fully deregulated the

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127. RENEWABLE FUELS ASS'N, COMMENTS ON THE RENEWABLE FUELS ASSOCIATION 44 (2009), *available at* http://www.ethanolrfa.org/page/-/objects/documents/2648/rfa_rfs2_comments_9-25-09.pdf?nocdn=1.

128. Emily Blas, *Monsanto Co. v. Geertson Seed Farms: Why the National Environmental Policy Act of 1969 Fails to Protect the Environment from Current Biotechnology*, 14 SUSTAINABLE DEV. L.J. 35, 37-39 (2011) (describing the regulatory process required for genetically engineered crops under the National Environmental Policy Act); Emily Marden, *Risk and Regulation: US Regulatory Policy on Genetically Modified Food and Agriculture*, 44 B.C. L. REV. 733, 745-84 (2003).

129. *Roundup Ready Alfalfa*, MONSANTO, http://monsanto.com/newsviews/Pages/roundup-ready-alfalfa-supreme-court.aspx (last visited Mar. 9, 2013).

130. Monsanto v. Geertson Seed Farms, 130 S. Ct. 2743, 2749 (2010).

131. *Id.* at 2761.

132. USDA ANIMAL AND PLANT HEALTH INSPECTION SERV. (APHIS), ROUNDUP READY ALFALFA, GLYPHOSATE-TOLERANT ALFALFA EVENTS J101 AND J163: REQUEST FOR NONREGULATED STATUS, FINAL ENVIRONMENTAL IMPACT STATEMENT (2010), *available at* http://www.aphis.usda.gov/biotechnology/alfalfa.shtml.

technology in early 2011.[133] Litigation is pending that alleges that deregulation poses significant risks to the environment, including increased herbicide application, herbicide-resistant weeds, transgenic contamination, and threats to endangered and threatened species.[134] In January 2012, a federal trial court denied the Plaintiffs' claims, and Plaintiffs have sought expedited review in the federal appellate court.[135] Because the standard of review of an agency decision on an environmental assessment is deferential, it is likely that APHIS' decision will stand.

A significant shift also has occurred in federal policy that may significantly reduce delays in deploying biotechnology. APHIS has determined that when no plant pests are used in genetic engineering and the crop does not have use for food or forage, it has no jurisdiction under the Plant Protection Act to regulate.[136] Thus, RR™ Kentucky Bluegrass has avoided the lengthy environmental review process like that of RR™ alfalfa.[137] If dedicated energy crops fit this exception, assumptions based on previous time-lags would not be appropriate in yield variables.

On the flip-side, potential yield *decreases* could result from the real possibility of more stringent water quality regulation by EPA under the U.S. Clean Water Act.[138] After years of state inaction, EPA is exercising "back stop" authority over state point source dischargers to force more stringent controls on non-point source nutrient pollution from agriculture.[139] EPA has issued nutrient loading limits for the Chesapeake Bay, and if states do not take concrete action to reduce nitrogen and phosphorus loading, EPA will impose stricter limits on point source

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133. USDA APHIS, RECORD OF DECISION, GLYPHOSATE-TOLERANT ALFALFA EVENTS J101 AND J163: REQUEST FOR NONREGULATED STATUS (2011), *available at* http://www.aphis.usda.gov/brs/aphisdocs/04_11001p_rod.pdf.

134. Ctr. for Food Safety v. Vilsack, D.C. No. 3:11-cv-01310-SC, 1009 (N. D. Cal. 2012).

135. *See id.* at 1010.

136. A. Bryan Endres, *New Hope for Dedicated Genetically Engineered Bioenergy Feedstocks?*, 4 GLOBAL CHANGE BIOLOGY BIOENERGY 127, 128 (2012).

137. *Id.*

138. Oliver Houck, *The Clean Water Act Returns (Again): Part 1, TMDLs and the Chesapeake Bay*, 41 ENVTL. L. REP. 10208, 10208 (2011).

139. *Id.* at 10221-22.

discharges.140 The American Farm Bureau Federation (AFBF) is challenging, along with other model aspects, EPA's modeled numerical limits in the courthouse, but deferential standards of review favor EPA.141 In Florida, EPA has entered into a consent decree with environmentalists to propose nutrient criteria.142 EPA has finalized the criteria, but environmentalists, farming, fertilizer, and industrial interests have waged court challenges against the rules as procedurally and substantively unreasonable.143 Environmental groups have also sued EPA for its refusal to take similar aggressive action in the Mississippi River Basin and the Gulf of Mexico, asking a court to order EPA to promulgate numeric criteria for nitrogen and phosphorus.144 What these actions portend is a future where fertilizer use by agriculture will be curtailed through regulation. Thus, models should consider future water quality restrictions with regard to yield as well as management practice assumptions.

b. Livestock Production and the Availability of Land

Federal Drug Administration (FDA) and EPA regulation of the livestock sector potentially affects model assumptions regarding pastureland available for conversion. Recently, a federal trial court ordered FDA to initiate withdrawal proceedings for antibiotic use in food-producing animals, partly based on a 1977 finding that the practice creates antibiotic

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140. *Id*. at 10226.

141. First Amended Complaint at 20-24, Am. Farm Bureau Fed'n v. EPA, No. 1:11-cv-0067 (M.D. Pa. Apr. 4, 2011) [hereinafter AFBF First Amended Complaint].

142. U.S. EPA, Consent Decree to Establish Federal Water Quality Standards for the State of Florida, Fla. Wildlife Fed'n, Inc. v. Jackson, No. 4:08-cv-00324-RH-WCS, (N.D. Fla. 2009), *available at* http://water.epa.gov/lawsregs/rulesregs/upload/Consent-Decree-re-numeric-water-quality-criteria-for-nutrients-for-the-state-of-Florida.pdf.

143. Fla. Wildlife Fed'n Inc. v. EPA, 647 F.3d 1296, 1299 (11th Cir. 2011) (dismissing appeal).

144. Amended Complaint at 1-2, Gulf Restoration Network v. Jackson, No. 2:12-cv-00677 (E.D. La. 2012).

resistance and threatens public health.145   Unless drug companies can prove the safety of their use, FDA will withdraw its approval.146   The potential consequences for the livestock industry are substantial.   Ninety percent of starter feeds, seventy-five percent of grower feed, and over fifty percent of finisher feeds contain antimicrobial drugs because of their claims to increase growth and health of the animals.147   One study predicts that many producers will become unprofitable and exit the industry unless consumers absorb the additional costs.148 Models that estimate the demand for agricultural land should incorporate the possibility of an antibiotics ban decreasing demand for animal feed, and the resulting effects on the demand for land.

The antibiotic ban may be especially harmful to DDGs feed derived as a co-product from biofuel production.   Modelers utilizing the expansion ("displacement") method within an LCA measure the impact of co-products by the value of the products they replace within the marketplace.149   Under this method, biorefineries may be given a GHG credit because DDGs satisfy some of the demand for animal feedstock normally grown on farmland,150 theoretically freeing up that farmland for other purposes.   However, antibiotics are sometimes added to the biofuel production process to prevent the growth of fermentation inhibiting bacteria.151   Traces of antibiotics remain in the DDGs

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145. Natural Res. Def. Council Inc. v. FDA, No. 1:11-cv-03562 (S.D.N.Y. Mar. 22, 2012).

146. *Id.* at 54.

147. B. Wade Brorsen et al., *Economic Impacts of Banning Subtherapeutic Use of Antibiotics in Swine Production*, 34 J. AGRIC. & APPLIED ECON. 489 (Jan. 2002) (presented at the Western Agricultural Economics Association Annual Meeting, Logan, Utah).

148. Michael Hogberg et al., *Banning Subtherapeutic Antibiotics in U.S. Swine Production: A Simulation of Impacts on Industry Structure*, 25 AGRIBUSINESS 314, 328 (2009).

149. Wang et al., *supra* note 37.

150. Michael Wang et al., *Energy and Greenhouse Gas Emission Effects of Corn and Cellulosic Ethanol with Technology Improvements and Land Use Changes*, 35 BIOMASS & BIOENERGY 1885, 1892 (2011).

151. NAT'L RESEARCH COUNCIL, COMM. ON ECON. AND ENVTL. IMPACTS OF INCREASING BIOFUELS, RENEWABLE FUEL STANDARD: POTENTIAL ECONOMIC AND ENVIRONMENTAL EFFECTS OF U.S. BIOFUEL POLICY 391 (2011).

and can be spread to livestock during the feeding process.[152] FDA has expressed concern over this contamination in the past,[153] increasing the probability that an antibiotic ban may affect the viability of DDGs produced in this method as an acceptable livestock feedstock. The possibility of DDGs—produced as co-products during the biofuel production process—becoming ineligible for consumption by livestock is the type of legal aspect that could be taken into account when considering DDG credits within LCA models.

Some models assume that livestock operations will be concentrated to free up pastureland for conversion to cropping. Pressure on EPA to regulate more stringently nutrient loading in watersheds has led to increased regulation of concentrated animal feeding operations (CAFOs) in the U.S.[154] In addition to increased governmental oversight, new EPA rules promulgated in response to a federal court order facilitate public participation in how effluent limitations are met through nutrient management plans.[155] In fact, courts have sanctioned citizen oversight not only over issuance of new discharge permits, but also to modifications to discharges in existing permits.[156] Forty-years of developing strategies in the U.S. for dealing with water pollution from CAFOs must caution modelers not only with regard to regulatory tie-ups in permitting, but in jurisdictions with less developed legal institutions, the potential for increased water quality problems that result from concentration of livestock operations. Models that measure GHG emissions by incorporating a scenario where CAFOs are utilized to free up pasture land for conversion to biomass should consider these factors.

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152. *Id.*

153. *Id.*

154. Hannah Connor, *Comprehensive Regulatory Review: Concentrated Animal Feeding Operations under the Clean Water Act from 1972 to the Present*, 12 VT. J. ENVTL. L. 275, 292-98 (2011).

155. Revised National Pollutant Discharge Elimination System Permit Regulation and Effluent Limitations Guidelines for Concentrated Animal Feeding Operations in Response to the Waterkeeper Decision, 73 Fed. Reg. 70,418 (Nov. 20, 2008) (codified at 40 C.F.R. pt. 412).

156. Terence Centner, *Challenging NPDES Permits Granted Without Public Participation*, 38 B.C. ENVTL. AFF. L. REV. 1, 1 (2011).

c. Biodiversity Protection

Modeling and the legal system are inextricably linked, with models informing regulatory decisions and regulatory decisions affecting models. This is particularly evident in the area of biodiversity. The Globio3 model estimates anthropogenic effects on biodiversity by utilizing cause and effect relationships between environmental drivers and resulting biodiversity impacts.[157] It has predicted a significant loss of biodiversity under a variety of bioenergy scenarios,[158] thus supporting the current trend of including biodiversity factors in both public and private bioenergy certification standards.[159] The Roundtable on Sustainable Biofuels (RSB), for example, requires buffer zones to prevent adjacent land from being affected, ecological corridors to prevent the negative effects of ecosystem fragmentation,[160] and requirements to maintain or enhance water[161] and soil quality.[162] Application of these standards change the assumptions made in models like Globio3.

Globio3 has a number of issues with assumptions, model structure, and underlying data that should be considered when evaluating scenario outcomes. It relies on causal connections between environmental drivers and environmental impacts that are based on a collection of scholarly studies, meaning that it relies on historical trends and is highly dependent on the accuracy of scholarly works.[163] The structure of Globio3 also makes it particularly susceptible to potential errors and therefore susceptible to litigation. Globio3 relies on input data concerning

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157. Alkemade et al., *supra* note 107, at 374.

158. *Id.* at 383-86.

159. *See generally* Jody M. Endres, *Legitimacy, Innovation and Harmonization: Precursors to Operationalizing Biofuels Sustainability Standards*, 37 S. ILL. L. REV. 1 (2012).

160. ROUNDTABLE ON SUSTAINABLE BIOFUELS, RSB-GUI-01-007-01, RSB CONSERVATION IMPACT ASSESSMENT GUIDELINES 6-14 (2011).

161. ROUNDTABLE ON SUSTAINABLE BIOFUELS, RSB-GUI-01-009-01, RSB WATER ASSESSMENT GUIDELINES 22 (2011).

162. ROUNDTABLE ON SUSTAINABLE BIOFUELS, RSB-GUI-01-008-01, RSB SOIL IMPACT ASSESSMENT GUIDELINES (2011).

163. Alkemade et al., *supra* note 107, at 376-77.

changes in environmental drivers provided by Image 2.4,[164] which is composed of a number of specialized models, each with their own set of assumptions.[165] IMAGE 2.4 also relies on data generated by GTAP for some of its calculations.[166] This web of connections increases the possibility of erroneous data or assumptions in one model affecting the accuracy of results produced by another one, compounding errors and spreading like a disease. Lastly, the lack of uniformity between terms utilized within the model and its underlying datasets creates added uncertainty with regard to compatibility between data sets. Globio3 is highly dependent on input data and utilizes land cover data from the Global Land Cover 2000 Map (GLC2000).[167] This data does not correspond, however, with the land classifications used within Globio3 and requires reclassification before it can be inputted into the modeling framework.[168]

B.   The Administrative Process as Gatekeeper

Transparency ensures modeling accuracy by facilitating detection of unrealistic or unconscionable assumptions within models. Openness also enables the public to verify that modelers' choices about what values to include and what assumptions to make are in line with societal values. For example, GTAP's high elasticity of demand for food set for less developed countries, in combination with its assumptions regarding the rise of food prices from competition for land, actually lead to decreased GHG emission values because it assumes that hungry people respire less.[169] The following sections examine ways in which administrative and judicial processes force transparency and ultimately determine the fate of models used in systems-level decision-making.

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164. NETH. ENVTL. ASSESSMENT AGENCY, INTEGRATED MODELING OF GLOBAL CHANGE: AN OVERVIEW OF IMAGE 2.4 173 (A.F. Bouwman et al. ed., 2006).

165. *Id.* at 9-16.

166. *Id.* at 14.

167. Alkemade et al., *supra* note 107, at 377-78.

168. *Id.* at 378.

169. STEVEN BERRY, BIOFUELS POLICY AND THE EMPIRICAL INPUTS TO GTAP MODELS 19 (2011), *available at* http://www.arb.ca.gov/fuels/lcfs/workgroups/ ewg/010511-berry-rpt.pdf.

a. The Administrative Procedure Act (APA)

The APA is one legal mechanism that facilitates increased transparency, and thus arguably accountability, in the modeling process. U.S. bioenergy implementing regulations for programs such as the RFS,[170] including modeling choices, have been subject to notice-and-comment rulemaking under the APA.[171] The APA ensures a baseline level of transparency by requiring that proposed rulemaking include the factual data on which it is based, the methodology used in obtaining and analyzing the data, and any major legal and policy considerations underlying the policy.[172] The Act holds federal agencies accountable for the scientific bases underlying their policies by prohibiting rulemaking from being based, in any part, on data not made available to the public.[173] Certain energy policies require a Scientific Review Committee to explain any contradictions between agency conclusions and the findings of the National Academy of Sciences.[174] Through this process, interested parties receive data and rationales behind policy choices based on modeling. Agencies must respond in the final rule to any significant comment, criticism, or new data provided during the public comment phase.[175]

Stakeholder involvement in the rulemaking process is crucial because post-rulemaking judicial intervention is limited in scope and skewed in favor of agency decisions.[176] The court will expect an agency to articulate a rational connection between the agency's decision and the underlying scientific facts,[177] but it will

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170. *See* U.S. EPA, *EPA Finalizes Regulations for the National Renewable Fuel Standard Program for 2010 and Beyond* (2010), http://www.epa.gov/oms/renewablefuels/420f10007.htm.

171. Administrative Proceedings and Judicial Review, 42 U.S.C. § 7607(d)(1)(E) (2006).

172. *Id.* § 7607(d)(3).

173. *Id.* § 7607(d)(6)(C).

174. *Id.* § 7607(d)(3).

175. *Id.* § 7607(d)(6)(B).

176. *Id.*; 42 U.S.C. § 7607(d)(9) (2006) (stating that a court may only set aside a final agency action when the action is "arbitrary, capricious, an abuse of discretion, or not otherwise in accordance with the law").

177. Oceans Advocates v. U.S. Army Corps of Eng'rs, 361 F.3d 1108, 1118 (9th Cir. 2004).

not substitute its own judgment for that of an agency.178 Indeed, the court is most deferential when assessing an agency's considerations in technical matters,179 particularly when the agency is "making predictions, within its [area of] special expertise, at the frontiers of science."180

b.   Incorporating "Adaptive Management" into Bioenergy Modeling

Predictive modeling of complex ecological, economic, and social systems, like those described in previous sections, begets high levels of scientific uncertainty due to a paucity of research and data needed to support solutions. EPA, in its regulatory impact analysis of the model used in the RFS, explicitly acknowledges gaps in and the fluid nature of the body of knowledge associated with various model parameters, particularly with respect to ILUC.181 In the absence of certainty, agencies must make value judgments within a range of modeled probabilities that often anger constituencies with contrary philosophical viewpoints. Adding to the problem of scientific uncertainty are agencies' limited capacity182 and interagency structures inept at information exchange.183 Courts' deference to agency decisions, often made pursuant to ambiguous statutes, further disincentivizes agency pursuit of greater knowledge and shrouds decisions from political accountability.184

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178. *Id.*

179. Lands Council v. Mcnair, 537 F.3d 981, 993 (9th Cir. 2008).

180. *Id.* (*quoting* Forest Guardians v. U.S. Forest Serv., 329 F.3d 1089, 1099 (9th Cir. 2003)).

181. *See* RIA, *supra* note 19, at 407-21 (EPA performs an uncertainty assessment in an attempt to identify all potential sources of uncertainty within international land conversion GHG emissions impact estimates).

182. J.B. Ruhl & James Salzman, *Climate Change, Dead Zones, and Massive Problems in the Administrative State: A Guide for Whittling Away*, 98 CALIF. L. REV. 59, 113-14 (2010).

183. Alejandro E. Camacho, *Can Regulation Evolve? Lessons from a Study in Maladaptive Management*, 55 UCLA. L. REV. 293, 337-39 (2007) (discussing lack of information exchange between agencies, and between agencies and regulated parties in relation to gauging whether adaptive management is working in Endangered Species Act Habitat Conservation Programs).

184. Holly Doremus, *Adaptive Management as an Information Problem*, 89 N.C. L. REV. 1455, 1463 (2011).

The APA facilitates public input to agency decision-making and requires agencies to tie available science and other information to any final rule. Putting aside for another day the argument that agency use of third-party models is less than transparent because the APA does not apply to model-construction outside the regulatory process, and that some model elements are proprietary, public participation through the APA can fill some knowledge gaps effectively. The APA's process prescriptions, however, do not guarantee rulemaking will generate the information necessary at the scale and complexity of the natural and economic systems that bioenergy modeling seeks to understand and predict. In situations where gaps in regulatory knowledge lead to uncertain causal relationships agencies can use "adaptive management" to create opportunities for continual learning that they in turn can deploy to better manage outcomes.[185] Rather than conducting a one-time analysis and issuing a final rule, adaptive management substitutes an "iterative, incremental decision-making process built around a continuous process of monitoring the effects of decisions and adjusting decisions accordingly."[186]

What role, if any, adaptive management can play in improving bioenergy models depends on the model. In the case of Chesapeake Bay watershed modeling, federal agencies such as USDA and EPA certainly could do much better in information production and sharing—"rewriting the learning" equation.[187] This likely would require at least one structural statutory change to allow USDA to share farmer-specific information with EPA.[188] In light of EPA's new strategies in the Bay, USDA could institute programs to gauge more fully the types of conservation practices all farmers use to protect water quality, versus relying primarily on conservation programs not adopted by the majority of

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185. *See, e.g.*, *id.* at 1457; Holly Doremus, *Precaution, Science, And Learning While Doing In Natural Resource Management*, 82 WASH. L. REV. 547 (2007); Camacho, *supra* note 183; J.B. Ruhl, *Regulation By Adaptive Management: Is It Possible?* 7 MINN. J. L. SCI. & TECH. 21 (2005).

186. Ruhl, *supra* note 185, at 28.

187. Doremus, *supra* note 184, at 1483-96.

188. Endres, *supra* note 159, at 5 (noting that section 1619 of the 2002 Farm Bill prevents reporting of individual farmer information).

farmers.189   This in turn would better inform models that the AFBF contends, in their lawsuit, neglect consideration of practices on the ground.190   EPA and USDA could pilot-test more widespread monitoring of these practices to determine their actual water quality improvements, which already is being done in watersheds in Minnesota.191   If EPA participated in pilot-programs like this in the Chesapeake Bay watershed, it could generate valuable feedback to validate its models.

On the other hand, GHG modeling that informs bioenergy policy decisions often involves "confounding variables" that require assumptions and aggregated data.192   Such modeling has led in some cases to calls for precaution in further incentivizing biofuels production.   In no case is this more evident than with controversial ILUC modeling.193   The economic modeling upon which ILUC calculations are based depends, in part, on measurement of the "net returns" to producers, which in turn theoretically motivate conversion of high carbon-value land to agricultural use.   Drivers behind net returns included in modeling are population growth, consumer tastes, international trade, weather, technology, local rules, and other factors that affect "the demand for land in different uses" and "production possibilities from different land-use alternatives."194   Models also use comparisons of historical changes in land use at certain geographic points, variation in land quality, and corresponding policies that may induce a particular producer choice.195

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189. Jody M. Endres, *Agriculture at a Crossroads: Energy Biomass Standards and a New Sustainability Paradigm?* 2011 U. ILL. L. REV. 513, 520 (2011).

190. *See infra* section III.B.4.

191. *Administrator Jackson, Secretary Vilsack Sign Historic Agreement With State of Minnesota to Help Farmers Protect Rivers, Streams and Lakes,* U.S. EPA (Jan. 17, 2012), http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9e fb85257359003fb69d/9e2aaef7cbcc2d468525798800692a58!OpenDocument.

192. Doremus, *supra* note 184, at 1474.

193. *See, e.g.*, Searchinger, *supra* note 64 (contending, based on modeling, that biomass-based fuel results in indirect land use change that negates any carbon benefit, and almost singlehandedly derailing any further biofuels initiatives).

194. Ruben N. Lubowski et al., *What Drives Land-Use Change in the United States? A National Analysis of Landowner Decisions* 4 (Nat'l Bureau of Econ. Research, Working Paper No. 13572, July 27, 2007), *available at* http://www.nber.org/papers/w13572.

195. *Id.* at 2.

From Doremus's "information problem" perspective, adaptive management applied to ILUC models' bioenergy carbon accounting regimes could address one possible shortcoming: that granular data related to land use choices in the U.S. used in ILUC modeling is not available for *Brazil*—the area where the land use change is theoretically "indirectly" induced.[196]   The underlying drivers of land use change in Brazil, such as policies and social factors, may be different enough to change modeled outcomes particularly for soy and corn-based fuels.   Instead of continuing to rely statically on existing ILUC calculations based on U.S. land use assumptions, EPA and third-party modelers could collaborate to generate Brazilian data and re-run models as information comes in.   This would impose increased costs, pose difficult research design and access questions, and in the end EPA would have to allow for adjustment through supplemental rulemaking if new information indeed would raise the carbon reduction.   Thus, whether adaptive management could solve "information problems" associated with ILUC modeling is uncertain.

To avoid these inextricable information problems associated with modeling, Congress could consider amending the RFS to better facilitate adaptive management.   If Congress eliminates the requirement that EPA assign an ILUC value to biofuels only attainable through speculative modeling, and instead would seek to curtail destructive land use change at actual sources vulnerable to land conversion (e.g., Brazil's Amazonia biome), it could achieve the goal of avoiding copious GHG emissions from deforestation without assigning the responsibility to biofuels policy.   Congress, for example, could authorize funding for increased cooperative efforts to study the root of deforestation problems in target countries, ranging from enforcement of existing laws[197] to underlying societal conditions such as rural

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196. The EPA explicitly identified this shortcoming in the models informing RFS. *See* RIA, *supra* note 19, at 448-49 (acknowledging that the global value assigned to the elasticity of transformation, a measure of how easily land can be converted, is based entirely off of a single study utilizing U.S. data).

197. *See generally* Onil Banerjee et al., *Toward a Policy of Sustainable Forest Management in Brazil*, 18 J. ENV'T & DEV. 130-53 (2009) (explaining Brazil's history of attempts to prevent deforestation through various initiative).

poverty and lack of educational opportunities. The learning from these initiatives could inform Congress' and regulatory agencies' future policy design aimed at combatting third-country deforestation. Generating knowledge directly on the causes of deforestation and using this information to adapt policy strategies would be more effective than incorporating complex economic and behavioral data into GHG models that have greatly hindered low carbon fuel initiatives.

Biofuel policy suffers similar information problems with regard to the "food versus fuel" controversy.[198] The RFS does incorporate adaptive management by requiring EPA, in setting the mandate after 2012, to determine whether biofuel production affects food prices.[199] Various third-party studies have attempted, through modeling, to determine the causal relationship between biofuels production and the food price spikes of 2008.[200] Some commentators have called for an end to "unethical" biofuels' mandates if they lead to shortages in food insecure countries.[201] As with ILUC calculations, food price modeling depends on, among other factors, complex interactions between demand for land, food production and consumption, and global markets.[202] Biofuels policy thus shoulders the dual heavy burden of preventing GHG emissions *and* starvation in an uncertain environment lacking component data on causality. Like with ILUC, to ensure adaptive management is most effective

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198. Michael Reilly & Dirk Willenbockel, *Managing Uncertainty: A Review of Food System Scenario Analysis and Modelling*, 365 PHIL. TRANSACTIONS OF THE ROYAL SOC'Y 3049, 3059 (2010) (stating that:

> [i]t is widely acknowledged that more work on the validity of model components used in integrated assessment studies is required, yet existing data sources often do not provide a sufficient basis for an ex-post comparison of simulation results with historical observations).

199. Energy Independence and Security Act of 2007 § 202(a), Pub. L. No. 110-140, 121 Stat. 1492 (codified at 42 U.S.C. § 7545(o)(2)(B)(ii)(VI)).

200. *See supra* text and accompanying notes 82-106; U.S. GOV'T ACCOUNTABILITY OFFICE (GAO), BIOFUELS: POTENTIAL EFFECTS AND CHALLENGES OF REQUIRED INCREASES IN PRODUCTION AND USE (2009) (examining the universe of various modeling attempts).

201. Damien Carrington, *Biofuels Transport Targets are Unethical, Inquiry Finds*, theGUARDIAN, Apr. 13, 2011, http://www.guardian.co.uk/environment/2011/apr/13/biofuels-targets-unethical.

202. *See supra* text and accompanying notes 82-106; Ujjayant Chakroverty et al., *Food Versus Fuel*, 1 ANN. REV. RES. ECON. 645 (2009).

Congress should fund on-the-ground research efforts to gather data on food insecurity holistically. This information could determine what ameliorative measures could be taken where food insecurity actually occurs and prevent precautious biofuels volumetric determinations based on uncertain probabilistic modeling.

Agencies (and Congress) rely on biofuels-centric modeling of GHG and food insecurity risk to substitute for cost-, time-, and technically-prohibitive experimentation. In the alternative, multidisciplinary collaborations between and within government agencies, academia, and other private stakeholders can generate comparative risk scenarios across the policy landscape that incorporate multi-criteria decision analysis (MCDA) to optimize decisions.[203] In turn, decision-makers can couple MCDA with adaptive management as acknowledgment of the uncertainty associated with GHG and food security policymaking and that no one single solution should be selected.[204] Instead, "a set of alternatives should be dynamically tracked to gain information about the effects of different courses of action."[205] This assumes, however that government can design "information architecture"[206] for gathering, diffusion, and tracking of critical data and that feedback loops facilitate iterative decision-making. Socio-environmental advocates who to date have been successful in exploiting modeling uncertainty may claim, too, that adaptive management is merely a "smokescreen" to justify moving forward with biofuels incentives.[207] This presents a monumental challenge to administrative law, and more broadly to policy design in a complex, future world of resource scarcity.

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203. Igor Linkov et al., *From Comparative Risk Assessment to Multi-Criteria Decision Analysis and Adaptive Management: Recent Developments and Applications*, 32 ENV'T INT'L 1072, 1073 (2006).

204. *Id.*

205. *Id.*

206. Doremus, *supra* note 184, at 1490.

207. Holly Doremus, *Adaptive Management, the Endangered Species Act, and the Institutional Challenges of "New Age" Environmental Protection*, 41 WASHBURN L.J. 50, 52 (2001).

c. The Data Quality Act

The Data Quality Act (known also as the Information Quality Act), requires the Office of Management and Budget (OMB) to set general government-wide guidelines to "ensure and maximize the quality, objectivity, utility, and integrity of information" disseminated to the public.[208] Disseminated information encompasses any information put into public view, such as federally-funded research, but excludes industry studies submitted in support of regulatory approvals.[209] While little history exists on the specific motivations behind the DQA, one commentator has suggested that the tobacco lobby was the architect behind its passage, intending to use it as a strategic tool in order to "control regulatory processes through information capture."[210]

At least on paper, agencies have put in place procedures with regard to how scientific information is considered by the agency, particularly with regard to "influential scientific, financial, or statistical information."[211] Information is "influential" when it has a clear and substantial impact on important public policies or important private sector decisions.[212] Influential information is subject to various levels of peer review.[213] When an agency conducts peer review of "highly influential information," it must make certain information available to the public, including: peer reviewers' directives, identities, reports, and agency responses to those reports.[214] When selecting peer reviewers who are not

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208. Consolidated Appropriations-Fiscal Year 2001, Pub. L. No. 106-554, § 515, 114 Stat. 2763A-153 – 2763A-154 (2000).

209. Wendy Wagner, *The "Bad Science" Fiction: Reclaiming the Debate Over the Role of Science in Public Health and Environmental Regulation*, 66 L. & CONTEMP. PROBS. 63, 68 (2003).

210. Wendy Wagner, *Administrative Law, Filter Failure, and Information Capture*, 59 DUKE L.J. 1321, 1400-01 (2010).

211. Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information Disseminated by Federal Agencies, 67 Fed. Reg. 8452, 8452-53 (Feb. 22, 2002).

212. *Id.* at 8455.

213. OFFICE OF MGMT. & BUDGET, FINAL INFORMATION QUALITY BULLETIN FOR PEER REVIEW 2-3 (2004), *available at* http://www.whitehouse.gov/sites/default/files/omb/memoranda/fy2005/m05-03.pdf.

214. *Id.* at 38.

government employees, the agency must adopt or adapt the NAS selection policies and must address any potential conflicts of interest.215   Agencies may consider a number of factors when determining the extent and depth of peer review required, including significance of the information, complexity and novelty of the science, and relevance to decision-making.216 OMB advises agencies to consider tradeoffs between costs and benefits and between the need for timeliness and depth of review.217

When an agency finalizes a rule, an interested party can request correction but cannot use a DQA claim as the basis for litigation.218   Successful action under the APA is unlikely, too, because agency action on a DQA petition is committed to its discretion by the DQA.219 A recent court decision has held that the DQA contains no substantive standards for timing of responses or the makeup of peer review panels, thereby leaving DQA implementation to an agency's discretion and precluding judicial review.220 Because the DQA lacks judicial "teeth," fears that agencies cannot take precautionary measures under conditions of scientific uncertainty have not materialized. Those with pretextual motives could use correction requests, however, to harass agencies and the scientists whose information they rely on.221 Correction requests also create delay and increase agency costs, which may disincentivize agencies from generating new science and updating models—a cornerstone feature of adaptive management.

To the extent that models incorporate legal interpretations that clearly and substantially impact final regulatory outcomes, OMB DQA peer review requirements may apply. Legal precedent does not neatly fit the dictionary definition of "objectivity," which lies at the core of DQA prescriptions: "expressing or dealing with

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215. *Id.* at 39.

216. *Id.* at 12.

217. *Id.*

218. Family Farm Alliance v. Salazar, 749 F. Supp. 2d 1083, 1090-91 (E.D. Cal. 2010).

219. *See generally* Heckler v. Chaney, 470 U.S. 821, 830 (1985).

220. *Family Farm Alliance*, 749 F. Supp. 2d at 1092-93.

221. NAT. RESEARCH COUNCIL, MODELS IN ENVIRONMENTAL REGULATORY DECISION MAKING 77-78 (2007).

facts or conditions as perceived without distortion by personal feelings, prejudices, or interpretations."[222]   Judicial precedents are set by human fact-finders (judges or juries) who cannot completely mask attitudes, beliefs, and biases. Indeed, studies demonstrate that judicial bias—particularly political bias—can affect judges' decisions.[223]   On the other hand, the Constitution sanctions, after all, human jurisprudence.   American jurisprudence's hierarchical precedential system, with clear rules as to applicability, acts as a check to bias. Subjectivity also is not limited to the legal profession. Evidence exists of motivated reasoning increasing the chances of finding false positives,[224] as well as confirmation and observational bias in qualitative research.[225] Peer review of modeling should consist of members from the legal profession skilled in interpreting both legal information (e.g., statutes, regulations, and other policies), and legally-informed data such as that examined in section III.A., to determine its utility and integrity under the DQA.

d.   Judicial Oversight of Predictive Modeling

The APA, adaptive management, and DQA provide opportunities to increase transparency, accuracy, and legitimacy of scientific models utilized by agencies. An aggrieved party, however, can assert an APA claim in federal court that agencies' use of modeling is "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law."[226] While courts cannot supplant their own judgment for that of Congress, statutes such as the RFS are ambiguous with regard to what modeling technique EPA should deploy. Congress often defers to agencies'

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222. *Objective,* MERRIAM-WEBSTER DICTIONARY, http://www.merriam-webster.com/dictionary/objective (last visited Mar. 9, 2013).

223. Stephanos Bibas et al., *Policing Politics at Sentencing*, 103 NW. U. L. REV. 1371, 1377-79 (2009).

224. Joseph Simmons et al., *False-Positive Psychology: Undisclosed Flexibility in Data Collection and Analysis Allows Presenting Anything as Significant*, 22 PSYCHOL. SCI. 1359, 1359-60 (2011).

225. Anthony Onwuegbuzie & Nancy Leech, *Validity and Qualitative Research: An Oxymoron?*, 41 QUALITY & QUANTITY 233, 235-37 (2007).

226. 5 U.S.C. § 706(2)(A) (1966).

specialized expertise, while the agency must exercise its power only within the boundary of the statute.[227]

The Chesapeake Bay Model (Bay Model) litigation provides an excellent example of how the judicial branch polices modeling both through review of the scope of an agency's authority under a statute, and the scientific complexity of modeling used to achieve statutory goals. The AFBF Plaintiffs (farming and home builder interests) claim that EPA overreached its Clean Water Act authority by requiring states to implement watershed implementation programs (WIPs) to reach modeled limits on non-point discharges.[228] They further argue that using the Bay Model as a basis for numeric limitations on non-point agricultural discharges, which in turn drives implementation of WIPs, contains flawed technical analysis.[229]

Under the two-part *Chevron* test, if the Clean Water Act clearly and unambiguously expresses the intent of Congress then EPA is bound by that intent.[230] If the district court finds the statute ambiguous, then it turns to whether EPA's interpretation is a permissible one.[231] It is during this second step that courts essentially apply the arbitrary and capricious standard of the APA.[232] Courts are particularly deferential to scientific judgments "at the frontiers of science."[233] In the absence of Congressional direction, agencies' decisions are based on value judgments, which courts generally recognize by focusing on procedural, reasoned decision-making over substantive review.[234] An agency thus, must base its decision on relevant information

227. Jason Czarnezki, *Shifting Science, Considered Costs, and Static Statutes: The Interpretation of Expansive Environmental Legislation*, 24 VA. ENVTL. L.J. 395, 396-98 (2006).

228. AFBF First Amended Complaint, *supra* note 141, at 20-24.

229. *Id.* at 24-27.

230. Chevron U.S.A. Inc. v. Natural Res. Def. Council, Inc., 467 U.S. 837, 842-45 (1984).

231. *Id.*

232. *Id.*

233. Lars Noah, *Scientific "Republicanism": Expert Peer Review and the Quest for Regulatory Deliberation*, 49 EMORY L.J. 1034, 1076 (2000).

234. *Id.*

and offer a plausible explanation consistent with that evidence.235 This "hard look" review can be said to overlap with (if not collapse into) the second *Chevron* step and the APA arbitrary and capricious standard.236

While deferential, hard look review has led to a number of rulemakings being remanded.237 Hard look review burdens already limited agency resources.238 Some evidence exists that agency resources must be diverted from addressing other problems when it must address hard look questions posed by a court.239 EPA's Council for Regulatory Environmental Modeling has published comprehensive best practices guidance on environmental model development, evaluation, and application.240 The guidance should serve as one way for EPA's modeling to pass muster under courts' hard look review and save agency resources from a court remand.

Focusing on the modeling challenge the AFBF Plaintiffs mount in the Bay Model litigation, the court is faced with untangling a technically complicated modeling regime consisting of an interconnected network of five models. The Watershed

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235. Matthew C. Stephenson & Adrian Vermeule, *Chevron Has Only One Step*, 95 Va. L. Rev. 597, 603 (2009); *see* Motor Vehicle Mfrs. Ass'n v. State Farm, 463 U.S. 29, 43 (1983) (holding that an agency decision will fail hard look review if the agency "offered an explanation for its decision that runs counter to the evidence before [it], or is so implausible that it could not be ascribed to a difference in view or the product of agency expertise").

236. Matthew C. Stephenson & Adrian Vermeule, *supra* note 235, at 603.

237. Richard J. Pierce, Jr., *Judicial Review of Agency Action in a Period of Diminishing Agency Resources*, 49 Admin. L. Rev. 61, 63 (1997) (stating that [m]any of the Supreme Court's administrative law decisions have major effects on allocation of agency resources); William Jordan, *Ossification Revisited: Does Arbitrary and Capricious Review Significantly Interfere with Agency Ability to Achieve Regulatory Goals Through Informal Rulemaking?*, 94 Nw. U. L. Rev. 393, 407-14 (2000).

238. Heath Brooks, *American Trucking Association v. EPA: The D.C. Circuit's Missed Opportunity to Unambiguously Discard the Hard Look Doctrine*, 27 Harv. Envtl. L. Rev. 259, 269 (2003) (stating that "hard look" results in increased agency expenditures); *see also* Richard Pierce, *Judicial Review of Agency Actions in a Period of Diminishing Agency Resources*, 49 Admin. L. Rev. 61, 64 (1997).

239. Jordan, *supra* note 237, at 416-18.

240. U.S. EPA, EPA/100/K-09/003, Guidance on the Development, Evaluation, and Application of Environmental Models (2009), *available at* http://www.epa.gov/crem/library/cred_guidance_0309.pdf.

model alone consists of 899 segments with twenty-four different types of land uses, utilizing 296 calibration stations.241   It accounts for input of manures, fertilizers, and atmospheric deposition of nutrients, using a variety of data sources such as agricultural censuses of animal populations, crops, fertilizer sales, and a variety of others.242   The Chesapeake Bay Water Quality and Sediment Transport Model, another linked model, calculates algal biomass, dissolved oxygen, and water clarity by taking into account bottom-water hypoxia, spring phytoplankton bloom, nutrient limitations, sediment-water interactions, and nitrogen budgets.243   The case exemplifies why the judge likely will not delve into the inner workings of the modeling, and instead will ask EPA for a reasoned explanation connecting the evidence before the agency with the decision to apply numeric limitations to non-point source discharges.

Aware of courts' deferential standards of review, the AFBF Plaintiffs fortify their substantive challenge with claims that EPA's procedure in adopting the models was exclusionary, and thus unlawful under the APA.244   EPA and the academics behind the models, however, did not develop the collection of models that make up the Chesapeake Bay Watershed behind closed doors with little to no input from stakeholders.   Instead, the models have been continuously developed and improved over "nearly 30 years of collaboration by federal, state, academic and private partners."245   Phase 5.3 Watershed Model, the newest version, was made possible with the help of EPA, Chesapeake Bay Program, U.S. Geological Survey, Interstate Commission on the Potomac River Basin, Maryland Department of the Environment, Virginia Department of Conservation and Recreation, and the University of Maryland.246   The level of cross-disciplinary and public participation is even greater than this impressive list may

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241. U.S. EPA, CHESAPEAKE BAY PHASE 5.3 COMMUNITY WATERSHED MODEL 1-23 (2010) [hereinafter WATERSHED MODEL 1-23].

242. *Id.* at 1-17.

243. *Id.* at 1-24.

244. AFBF First Amended Complaint, *supra* note 141, at 27-30.

245. *Modeling*, CHESAPEAKE BAY PROGRAM, http://www.chesapeakebay.net/about/programs/modeling (last visited Mar. 9, 2013).

246. *Phase 5.3 Watershed Model*, CHESAPEAKE BAY PROGRAM, http://www.chesapeakebay.net/about/programs/modeling/53/ (last visited Mar. 9, 2013).

suggest, as the Chesapeake Bay Program consists of dozens of partnerships between academic institutions, federal agencies, and non-governmental organizations.247   The Bay Model is also distributed as a community model (i.e., it is freely available over the internet as an open source),248 which encourages efficient and more widespread use of the model and allows independent analysis.249 In sum, while the AFBF Plaintiffs' modeling claim is not likely to succeed, and no state has joined in the litigation, it provides an excellent example of models' vulnerability to litigation and how administrative and judicial processes determine models' ultimate fate.

IV. CONCLUDING REMARKS

My article challenges the common misconception that lawyers and laws are tangential to scientific modeling. Predictive modeling used in bioenergy and environmental regulatory applications must recognize the legal discipline's structural and procedural roles in building better predictive scenarios and ultimately, solutions.   The lack of engagement of the legal profession in modeling science speaks to the higher procedural need to build "information architecture"250 to facilitate the substantive cross-disciplinary collaboration critical to systemic environmental problems such as climate change, food insecurity, water pollution, and biodiversity.

Meanwhile, although all stakeholders, whether industry, academic, or environmental, make claims that modeling must be based solely on "sound science," when conditions of high uncertainty exist and potential for conflict is high, it must be recognized that modeling inputs and operational choices all involve value judgments made by both scientists and regulatory agencies on society's risk tolerances.251 Courts, as final arbiters

247. *Modeling, supra* note 245.

248. WATERSHED MODEL 1-23, *supra* note 241.

249. *Id.*

250. Doremus, *supra* note 184, at 1490.

251. *See generally* Holly Doremus, *Using Science in a Political World: The Importance of Transparency in Natural Resource Regulation*, *in* RESCUING SCIENCE FROM POLITICS: REGULATION AND THE DISTORTION OF SCIENTIFIC RESEARCH (Wendy Wagner & Rita Steinzor eds., 2006).

of model disputes, must be astute through their jurisprudence in encouraging agencies to fully explain both the universe of science upon which modeling depends, and the value judgments inherent in science, law, and rulemaking itself.252   If courts can successfully expose these distinctions, stakeholders and society perhaps can better accept the choices agencies make among the range of possibilities. Those possibilities are both uncertain and complex, particularly as demonstrated in the new bioenergy paradigm, and must unfortunately shoulder debate on both climate change and food security.

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252. *Id.* at 160 (concluding that "hard look" judicial standards of review, as one of their perhaps most useful and beneficial roles, can force agencies to "reveal the value choices that determine regulatory decisions").