**Manuscript 1: Expert elicitation of salamanders**

**Title:**

* Predicting salamander occurrence when data is lacking using expert opinion

**Journal:**

* Conservation evidence (Making amphibian conservation more effective; Meredith et al. 2016)
* Conservation biology (martin et al. 2012, Addison et al. 2015)

**Introduction:**

* Expert knowledge is widely used in conservation b/c of the complexity of problems, relative lack of empirical data and imminent nature of decisions.
* This knowledge typically takes the form of mental models without explicit consideration of biases (i.e., experts are called on to express opinions in a qualitative and non-transparent way). In fields where there is extensive expert knowledge, yet little published data, the use of expert information as priors for ecological models is a cost-effective way of making more confident predictions about the effect of management on biodiversity.
* Increasing use of expert elicitation methods to help inform conservation decisions (identify important hypothesis and parameter uncertainties to resolve). Probabilistic framework that accounts for uncertainty (confidence) of multiple experts.
* Examples of expert elicitation used to parameterize models that inform management decisions (from Martin et al. 2012):
  + Johnson et al. 2010 – use to parameterize Bayesian network to evaluate population viability of cheetahs (X experts)
  + Runge et al. 2011 – use to identify alternative hypotheses and uncertainties affecting mgt of whooping cranes (X experts)
  + O’Neill et al. 2008 – used to quantify trends and range of effects of climate change on polar bears (10 experts)
  + Martin et al. 2005 and Kuhnert et al. 2005 – used to evaluate effects of livestock grazing intensity on austrialian woodland birds in Bayesian GLM (20 experts)
  + Smith et al. 2011 – Bayesian networks
* Examples from Charney 2012:
  + Expert opinion is increasingly used to parameterize models in the absence of data and as Bayesian priors to supplement sparse data (Yamada et al., 2003; Martin et al., 2005; Denham and Mengersen, 2007; Griffiths et al., 2007; Mac Nally, 2007; O’Neill et al., 2008; Low Choy et al., 2009; O’Leary et al., 2009; Murray et al., 2009; James et al., 2010). Yet, when lacking data, expert opin- ion does not necessarily offer an improvement (Cox, 2000; Pearce et al., 2001; Seoane et al., 2005).
* Canessa: Where empirical measures of the required parameters for a situation of interest are not available, expert judgment can help develop plausible estimates that most effectively inform decisions (Speirs-Bridge et al. 2010; Martin et al. 2012). Such methods can prove especially valuable in the management of threatened species, where the need to make urgent decisions leaves little time for the collection of further information.
* An expert is someone who has substantial information on a particular topic that is not widely known by others and who is offered deferred to for their knowledge and interpretation.
* Expert-elicitation (in general) is composed of 5 steps:
  + Deciding how information will be used
  + Determining what to elicit
  + Designing elicitation process
  + Performing elicitation
  + Translating elicited information into quantitative statements that be used in ecological models (to ultimately help make decisions).
* Additional important steps:
  + How to work with multiple experts
  + How to combine multiple judgements (treat as equal or weights, average or ranges)
  + Minimizing bias in elicited information
  + Verifying accuracy of expert information
* Limited information about amphibians (salamanders) region-wide and are in decline – call for experts to aid in identifying parameters to be used in both predictive and decision models to evaluate range of outcomes of conservation actions.
* Objective:
  + Conduct expert elicitation for Plethedontide (stream obligate for at least some stage of life-history?): Desmognathus, Gyrinophilus, and Eurycea
  + G. porphyriticus; spring salamander, D. fuscus; dusky salamander, and E. bislineata; two-lined salamanders
  + These species also are known to co-occur in streams with fishes (brook trout), an important predictor/competitor affecting salamanders.
  + Use insights to build predictive co-occurrence models under climate change (Hocking et al prediction paper), and evaluate land-protections strategies (Kate et al. optimization paper).
  + Questions:
    1. How much do expert opinions agree with field-observations (do we have any?)
    2. How variable are expert opinions (mean and confidence)
    3. Which uncertainties are most important for predicting salamander occupancy (this or hocking prediction paper just for salamanders – model sensitivity based on expert uncertainty?)

**Methods:**

*What to elicit?*

* Stats (mean and confidence): participants provide optimistic and pessimistic consequence estimates to represent 90% credible bounds (reflecting 3-point or 4-point elicitation approach (Speirs-Bridge et al. 2010)).
* Match scale of actions with scales for response (catchment-level actions = occupancy of salamanders). Should we elicit multi-state occupancy (0, low, medium, some, lots)?
* List of variables (Table 1):
  + Baseline states (intercepts)
  + Catchment-level effects
  + Upstream-level effects
  + Buffer-level effects
  + Upland-level effects
  + Regional-differences
  + Additional spatial autocorrelation?
  + Climate-effects (temperature and flow)
  + Interspecific effects (with trout)

Table 1. List of variables to elicit (also see BBN).

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Description | Unit | Interpretation |
| Baseline occupancy |  | Probability (0 to 1) | Probability of any catchment, on average, being occupied (intercept) |
| Local Catchment Forest cover | The percent forest cover with a catchment influence occupancy of salamanders | 1 unit increase in forest cover (i.e., X acres randomly throughout the catchment) |  |
| Upstream Catchment Forest Cover |  |  |  |
| Local Forest Buffer |  |  |  |
| Upstream Catchment Forest Buffer |  |  |  |
| Stream Temperature |  |  |  |
| Fish Presence |  |  |  |
| Network Position |  |  |  |
| Local Catchment Wetland Cover |  |  |  |
| Upstream Catchment Wetland Cover |  |  |  |
| Conditional on region/province? | Which responses are conditional on region | Appalachian Plateaus, Valley and Ridge Province, Blue Ridge Province, Piedmont Province, Coastal Plain, New England, Adirondack Province, Interior Low Plateaus | The effects of another variable varies depending on which province your in (due to underlying geology, ground-water connectivity, and other unexplained factors) |

Example BBN for elicitation of variables (see Ban et al. 2015)

*Elicitation process (to manage bias):*

* Method: email survey, telephone interview, face-to-face interview, group meeting?
* Experts Identified:
  + Criteria – snowball method question? Aks: Who would you go to for expert judgments on salamander ecology for these three species? Why?
  + Years of direct research on salamanders
  + Number of publications involving salamanders

Table 2. List of salamander experts for consideration:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Last, First | Current Agency | Contact | Years (Sal) | No. Publications (Sal) |
| Grant, Evan | USGS |  |  |  |
| Fields, Will | USGS |  |  |  |
| Hocking, Dan | USGS |  |  |  |
| Lowe, Winsor |  |  |  |  |
| Barrett, Kyle | Clemson |  |  |  |
| Maerz, John | UGA |  |  |  |
| Stuart, X |  |  |  |  |
| Mendelson, Joe |  |  |  |  |
| Steen, David | Auburn |  |  |  |
| Miller, David | Penn State |  |  |  |
| Cecala, Kristen |  |  |  |  |
| Sutton, Bill |  |  |  |  |
| Milanovich, Joe |  |  |  |  |
| Baily, Larissa | Colorado State |  |  |  |
| Muths, Erin | USGS |  |  |  |
| Adams, Mike | USGS |  |  |  |

* Expert will draw on their own expertise, scientific publications and management agency reports (we created a list of relevant documents and provided to experts; Table 1).

Table 3. List of relevant literature provide to experts

|  |  |  |
| --- | --- | --- |
| Paper | Species | Variables |
|  |  | Baseline states (intercepts) |
|  |  | Catchment-level effects |
|  |  | Upstream-level effects |
|  |  | Buffer-level effects |
|  |  | Upland-level effects |
|  |  | Regional-differences |
|  |  | Additional spatial autocorrelation? |
|  |  | Climate-effects (temperature and flow) |
|  |  | Interspecific effects (with trout) |

*Analysis*

* Comparisons of means and confidence across experts
* Weighted averages (various methods for combining experts?)
* Use to make simple salamander only-predictions (which uncertainties matter most?)

**Results**

* Number of experts
* Comparisons across experts (what was consistent and what wasn’t)
* Weighted averages across experts
* Which uncertainties influenced occupancy predictions the most?
* New hypothesis/insights from experts

**Discussion**

**Literature**

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Runge, M. C., Converse, S. J. & Lyons, J. E. Which uncertainty? Using expert elicitation and expected value of information to design an adaptive program. Biol. Conserv. **144,** 1214–1223 (2011).