Conservation Opportunity Areas in Pennsylvania for inclusion in the 2015-2025 State Wildlife Action Plan

A Case Study from the Structured Decision Making Workshop
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Decision Problem

Identify combinations of locations and optimal actions to protect and enhance Pennsylvania Species Greatest Conservation Need for future generations. To do this we need to develop a spatially explicit tool that will serve to support a range of allocation decisions within the next 10 years in a transparent manner.

The Need

The 2005 Pennsylvania State Wildlife Action Plan (SWAP) includes more than 750 "prioritized implementation actions" but lacks geospatial guidance for targeting these actions to maximize conservation benefits for Species of Greatest Conservation Need (SGCN) and their habitats. The lack of spatially explicit priority areas was an early criticism of the plan, and reinforced by over 50 statewide conservation partners at a 2012 Wildlife Diversity Forum, hosted by the Pennsylvania Game Commission (PGC). With increasing threats and dwindling budgets, we need a more coordinated approach to implementing conservation actions.

Pennsylvania is currently revising the 2005 SWAP (due September 2015) and the 2015 SWAP Steering Committee, composed of Pennsylvania Fish and Boat Commission (PFBC) and PGC program administrators, has committed to spatially depict priority areas for conservation action (i.e., conservation opportunity areas) in the 2015 version to encourage efficiency and effectiveness of collaborative conservation efforts. This process will provide a transparent and

scientifically defensible approach to the identification of Conservation Opportunity Areas leading to operational actions for the benefit of SGCN.

Background

Legal, regulatory, and political context

State Wildlife Action Plans are congressionally mandated for states to receive federal State & Tribal Wildlife Grants Program funds. A State Wildlife Action Plan is a non-regulatory, comprehensive conservation planning document, developed by each state, in conjunction with conservation partners and the interested public. The plan categorizes Species of Greatest Conservation Need (SGCN), describes habitat extent and condition, identifies threats to priority species and associated habitats, and specifies prioritized conservation actions to abate threats to species and habitats. The Pennsylvania Fish & Boat Commission and Pennsylvania Game Commission, administrators of the State Wildlife Action Plan and State & Tribal Wildlife Grants Program funds, are leading a required 10-year comprehensive review and revision of the original 2005 SWAP, with a completed revision submitted to the U.S. Fish and Wildlife Service by 30 September 2015.

Many states across the country identified Conservation Opportunity Areas (Fig. 1) in the 2005 versions of their State Wildlife Action Plan. There appeared to be no consistent methodology for identifying these areas, thus leaving open options for Pennsylvania's approach.

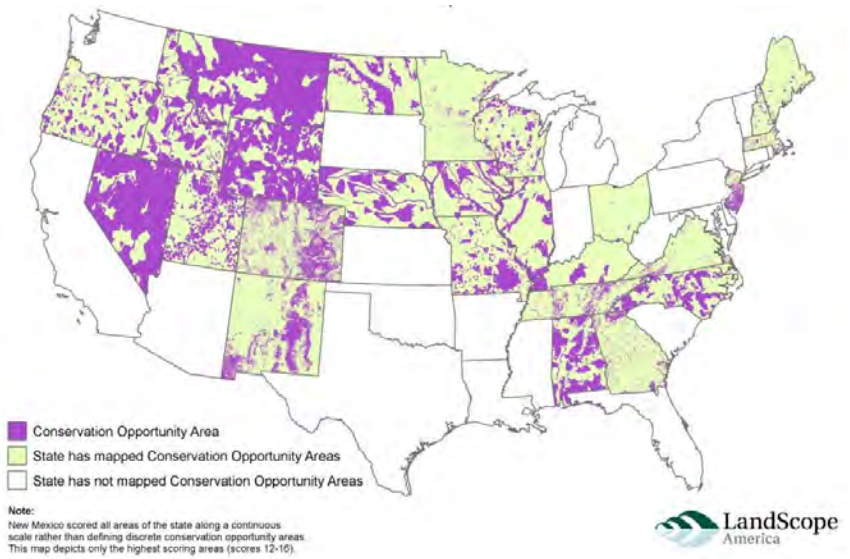


Figure 1. Conservation Opportunity Areas identified in the lower 48 states 2005 State Wildlife Action Plans. Map provided by the Association of Fish and Wildlife Agencies, May 2009.

Ecological context

The landscape of Pennsylvania provides an ecological convergence of many major physiographic regions such as the Great Lakes, Upper Mississippi/Ohio River Basin, Appalachian region, Chesapeake Bay Watershed, and Atlantic slope. Within this ecological setting, topographic variation and habitat composition provide additional complexity for the 209 vertebrate and 425 invertebrate species identified as SGCN in the 2005 SWAP. Consequently, the diversity and distribution of species contribute to overlapping and, potentially conflicting, management actions. This ecological framework, coupled with directives from the 2015 SWAP Steering Committee, provide background for the decision problem.

Decision Structure

The delineation and use of Conservation Opportunity Areas poses long-term resource management implications, as well as potential social and political concerns. Thus, the PGC (and PFBC) determined that a formal process would be the best approach for understanding the implications and role of COAs in the SWAP revision. In response to a request-for-proposals from the National Conservation Training Center, the Commissions submitted a proposal to work on this topic using a Structured Decision Making (SDM) process (Figure 2). A team of resource professionals from federal & state agencies, institutions and non-governmental organizations were assembled to review this problem. A sub-group of these members, along with the SDM coaches, developed the prototype discussed in this document. This overview will reference the stages in this process.

Figure 2. ProACT, steps of the Structured Decision Making process (Hammond *et al*. 1999). Note: This figure will be used repeatedly throughout this document, but will not be labeled with each subsequent use.

Modifications to the problem statement

As described in Hammond *et al*. (1999), to make the best decision it is critical to ensure that the right problem is being addressed. Throughout the SDM process, the team continually evaluated the problem statement for accuracy, focus, and purpose of the required decision. From this ongoing assessment, the focus of the problem transitioned from identifying well-defined locations and actions (*i.e.*, "where to allocate limited resources within the next 10 years on land protection and habitat management"), to the development of a decision tool that could allow users to assess management options for SGCN. This revised approach is expected to allow more versatility and functionality for a broad range of users and to be less restrictive in the identifying the location for actions.

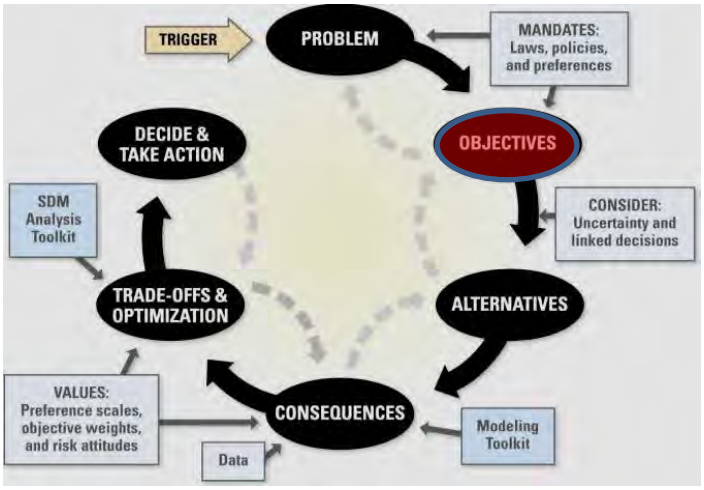
Consequently, the resulting problem statement was adjusted to an approach that will "Identify combinations of location and optimal actions for Pennsylvania Species Greatest Conservation Need (SGCN) using a spatially explicit tool that will serve to support a range of allocation decisions within the next 10 years for the protection and enhancement of these species for future generations."

Objectives

Through the SDM process, we identified two fundamental objectives:

1) Conservation of SGCN
2) Minimize cost

<u>Fundamental Objective 1: Conservation of SGCN</u>



The conservation of SGCN represents the overall purpose of the Pennsylvania SWAP and thus it is logical for this objective to be "fundamental". This Fundamental Objective and supporting Means Objectives are founded in the protection and enhancement of habitat (Figure 3). These Means Objectives will support quality habitat on which SGCN depend and can therefore help protect against the broad array of threats to SGCN. This enhanced habitat is expected to contribute to increased survival and reproduction of SGCN. By maintaining or increasing SGCN survival and reproduction, the conservation status of SGCN will then be improved.

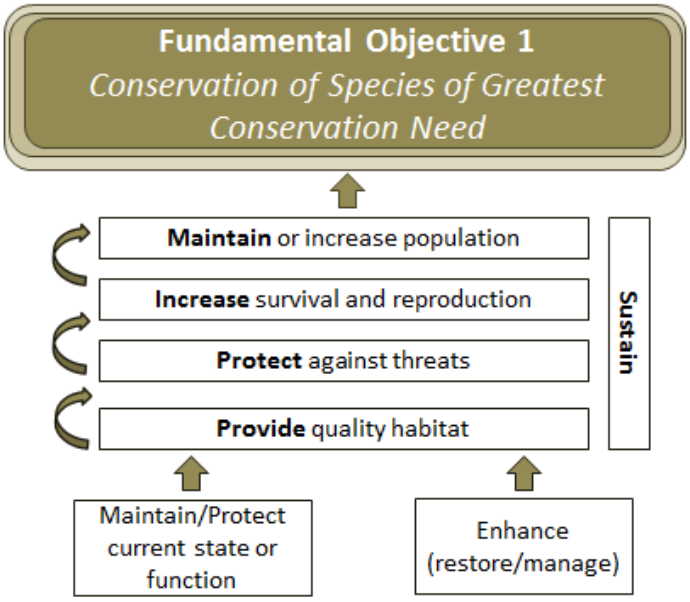


Figure 3. Fundamental Objective 1, conservation of Species of Greatest Conservation Need, for Pennsylvania Conservation Opportunity Areas in the 2015 State Wildlife Action Plan.

Fundamental Objective 2: Minimizing Costs

Although the primary fundamental objective for most natural resource agencies and organizations is the conservation of species and habitats, financial costs are an overarching constraint on the implementation of conservation actions to meet this objective. Costs can include financial input for equipment & materials, expenses incurred through use of staff time and other operational outlays. Costs can also be incurred through human conflict (Figure 4). For example, a municipality opposing a proposed conservation action (*e.g.*, dam removal, timber stand improvement) may require considerable effort (*i.e.*, staff time) to address these concerns. This may result in weighing options to assess whether benefits exceed anticipated costs. For this fundamental objective, the intent is to minimize costs by operating within budget and reducing human conflict (*i.e*., means objectives).

Other: Process Objective

Beyond fundamental objectives, "transparency" was recognized as a third important feature of COA development and characterized as a "process objective". Transparency is not involved in "trade-offs" associated with determining actions, yet it is critical to support SGCN conservation. Transparency helps:

- Create buy-in from multiple users and highlights the importance of these areas.
- Ensure replication and openness when the process is modified.
- Build public support.
- Maintain involvement of cooperators & partners.
- Promote simplicity.

Decision Analysis

Overview: We discussed the development of a decision support tool as means to effectively address the problem of identifying combinations of location and optimal actions for Pennsylvania Species of Greatest Conservation Need (SGCN). Described below is a draft approach for developing this decision tool. Prior to initiating this approach, we will have identified *conservation action alternatives* for each habitat (*i.e*., protect or enhance) based on species' habitat requirements and the current state of the system. *Consequences* of action alternatives on SGCN conservation will depend on the potential future state of the system.

Step 1: Rank SGCN Tiers.

In Pennsylvania's 2005 State Wildlife Action Plan, the 609 SGCN are grouped by priority Tiers 1-5, with Tier 1 containing species that are of "immediate concern" (*i.e.*, those having the greatest urgency for management and protection) whereas Tier 5 holds species that are common, but are recognized to be under threat or potential for decline. Tiers 2 (high-level concern), 3 (PA responsible), 4 (PA vulnerable) have qualities that are less distinct as Tiers 1 and 5, but nevertheless are recognized as requiring significant conservation effort.

With the large number of SGCN in the PA SWAP, there is a need to establish priorities for the limited funds. In the SDM workshop, team members were asked to rank the Tiers using two rules, 1-the maximum score allowed across all Tiers was 100 and, 2-a score for a lower tier could not exceed the score of higher tier. From this ranking process, the team provided Tier 1 species with nearly half (48%) of the available points (Table 1). These rank values will serve as a significant weighting factor in developing the decision tool.

Table 1. Sample ranks of SGCN Tiers, as determined by PA COA Structure Decision Making Team members. Tier 1 represents Immediate Concern species; Tier 5 represents Maintenance Concern species. Each member was given 100 pts to divide among tiers. Lower priority tiers could not receive more points than higher priority tiers.

SGCN Tier	**1**	**2**	**3**	**4**	**5**	
	50	25	10	10	5	
	40	25	20	10	5	
	50	30	10	10	0	
	50	25	10	10	5	
	60	15	10	10	5	
	35	30	25	5	5	
Total	285	150	85	55	25	
Percent (*i.e.*, Rank Value)	**48**	**25**	**14**	**9**	**4**	100

From this ranking process and the priority Tier, a SWAP SGCN Value was assigned to each species (*e.g.*, Table 2).

Table 2. Representative approach for assigning values to SGCN based on rank values generated by expert input.

Species	SWAP Conservation Tier	SWAP SGCN Value
1	2	25
2	2	25
3	3	14
4	3	14
5	4	9
6	1	48
…	…	…
609	5	4

Step 2: Integrate species occurrence probabilities and SGCN weighted values.

The rank value for each SGCN coupled with the probability of occurrence for that species at any location will help inform possible conservation actions at that location. The potential actions and tradeoffs are discussed later in this document. For this step, species distribution models will help determine the likelihood of a species occurrence. From this, landscape-scale value contours will emerge based on the SGCN weighted values (Figure 4). Overlaying 'high value' species' distributions, including occurrence probabilities, and additively combining the contour values, will create a consolidated SGCN value map. Different areas across the state will have comparative values for their potential to host SGCN species. This can be helpful to highlight areas to consider work initially (*e.g.*, SGCN hotspots) while subsequent steps are developed.

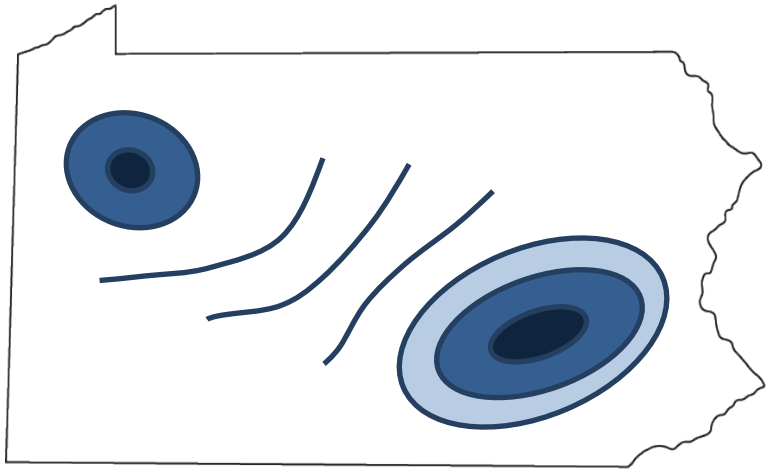


Figure 4. Illustration of a contour values resulting from the probability of occurrence and weighted SGCN value. The dark circle indicates a high probability of occurrence and high SGCN value.

Step 3: Specify species-habitat associations.

A major assumption of this process is that species distribution and abundance are influenced by habitat type and change in habitat condition (quality). In a simplistic example (Table 3), a grassland obligate species (Species 1) is found in "grassland habitats" whereas species tolerant of grasslands or wetlands (Species 2) would be noted as occurring in these habitats, but not in forests (Table 3). This process of associating species and habitats would be conducted for all SGCN.

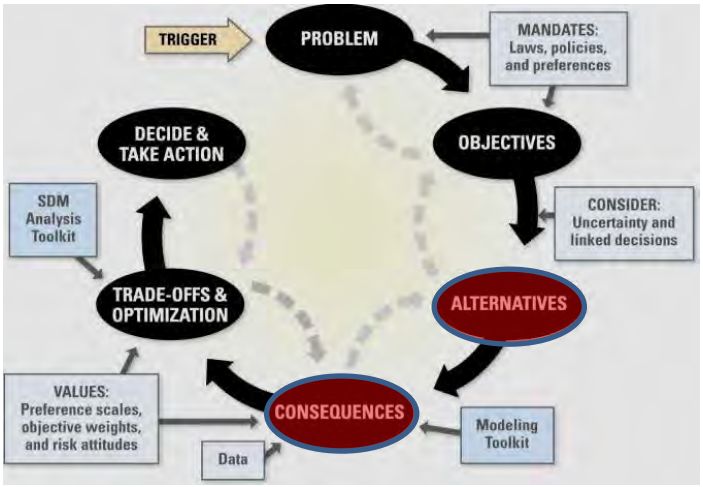
Table 3. Examples of species-habitat associations that would be developed for each SGCN.

Species	**Grassland-Poor**	**Grassland-Moderate**	**Grassland-Good**	**Wetland-Poor**	**Wetland-Moderate**	**Wetland-Good**	**Early Successional Forest-Poor**	**Early Successional Forest-Moderate**	**Early Successional Forest-Good**	Habitat Requirements
1	**1**	**1**	**1**	0	0	0	0	0	0	*Grassland obligate*
2	**1**	**1**	**1**	**1**	**1**	**1**	0	0	0	*Grassland or wetland*
3	1	1	1	0	0	0	1	1	1	*Grassland, shrubby grassland, and young forest*
4	0	0	1	0	0	1	0	0	0	*High quality grassland and wetland habitats*
5	0	0	0	**1**	**1**	**1**	0	0	0	*Wetland obligate*
6	0	0	0	**1**	**1**	**1**	0	0	0	*Wetland obligate*
7	0	1	1	0	1	1	0	0	0	*Medium quality grasslands or wetlands*
8	0	1	1	0	1	1	0	0	0	
9	0	0	0	0	0	0	1	1	1	*Facultative forest*
10	1	1	1	1	1	1	1	1	1	*Anywhere but old dense forests*
…	.	.	.	.	.	.	.	.	.	…
609	#	#	#	#	#	#	#	#	#	*Species habitat association for species 609*

Step 4: Spatially depict threats to species and habitats in Pennsylvania.

Proximate threats to species and habitats can influence the persistence of a species within a known distribution or the likelihood of a species occurrence (*i.e.,* recovery potential). In addition to the species-habitat associations, it is necessary to identify the possible future state of a habitat to understand the probability of conversion (see Table 7) to another habitat type or condition. Alternative actions (see Step 5) for species and habitats are considered in light of the identified threats.

Step 5: Identify alternative actions and consequences.



Managers are faced with a multitude of possible actions within any landscape, ranging from no action to intensive management for a particular species. Therefore, we next determined alternative actions for each habitat type and condition, and the habitat (and condition) resulting from the specified action. A generalized, relative cost of each action was also considered because costs can influence management decisions (Table 4). For the current habitat quality of each grassland habitat, five alternative actions were identified, ranging from "do nothing" to "planting". The consequence of these actions are noted in the "new habitat" and "new habitat quality" columns.

Management decisions will have varying impacts on Species of Greatest Conservation Need, and these consequences must be considered during the decision process. To illustrate these consequences, we identified alternative conservation actions for three major habitat types and eight species (Table 5). In this example, three alternative actions for forest habitats include protection (*i.e.*, easements or acquisitions), and two enhancement actions of 'no timber harvest' and 'timber harvest' (*i.e.*, timber stand improvement). Impacts to the eight species were determined as either beneficial (+), neutral (0), or negative (-). The outcome demonstrates, logically, that forest species often benefit from forest management actions, but this outcome is not always consistent and may be influenced by local conditions and certain species-habitat requirements. By comparison, agricultural/grassland species are negatively impacted by all forest related actions. However, these same grassland species benefit from actions that maintain or enhance grasslands. The complexity of identifying appropriate actions for species is demonstrated in areas with species requiring competing needs. For example, golden-winged warblers tend to favor habitats of young forests whereas cerulean warblers and scarlet tanagers prefer more mature stands. So, within a single habitat type, actions implemented may differentially affect the species present. Subsequently, action decisions will need to be considered in the context of the species present within the habitat type. In aquatic systems (streams), the proposed actions of "protection", "dam removal" and "forested buffer creation" were either neutral or positive for all species with the exception of forested buffer creation negatively impacting the grassland-favoring Henslow's sparrow.

Table 4. Alternative actions and outcomes based on current habitat type and condition and associated cost of implementing the conservation action, using grassland habitat as an example. This approach would be repeated for all habitat types.

Current Habitat	Current Habitat Quality	Actions	Action Cost	New Habitat	New Habitat Quality	*Transition Shorthand*
Grassland	Poor	Do Nothing	0	Grassland	Poor	GP -> GP
		Pull Invasives	$	Grassland	Moderate	GP -> GM
		Burn	$$	Grassland	Good	GP -> GG
		Mow	$			GP -> GG
		Plant	$$	Young Forest	Good	GP -> EFG
Grassland	Moderate	Do nothing	0	Grassland	Poor	GM -> GP
		Pull Invasives	$	Grassland	Moderate	GM -> GM
		Burn	$$	Grassland	Good	GM -> GG
		Mow	$			GM -> GG
		Plant	$$	Young Forest	Good	GM -> EFG
Grassland	Good	Do nothing	0	Grassland	Moderate	GG -> GM
		Pull Invasives	$	Grassland	Good	GG -> GG
		Burn	$$	Grassland	Good	GG -> GG
		Mow	$	Grassland	Good	GG -> GG
		Plant	$$	Young Forest	Good	GG -> EFG

Table 5. Simplified example of a consequence table of alternative actions for Species of Greatest Conservation Need in forest, stream and grassland habitats, where (+) is a positive effect, (-) is a negative effect, and (0) is neutral to promoting a species at a location.

		Actions								
		Forest			**Aquatic (Streams)**			**Grassland**		
	Species	Protect	No Timber Harvest	Timber Harvest	Protection	Dam Removal	Forested Buffer Creation	Protect	Maintain (mowing, burning)	Grassland Creation
Forest	Golden-winged Warbler	+	-	+	0	0	0	0	0	0
	Cerulean Warbler	+	+	-	0	0	+	0	0	0
	Scarlet Tanager	+	+	-	0	0	0	0	0	0
	American Woodcock	+	-	+	0	0	+	0	0	0
Aquatic	Yellow Lampmussel	+	+	0	+	+	+	0	0	0
	Brook Trout	+	+	-	+	+	+	0	0	0
Agriculture & Grasslands	Henslow's Sparrow	0	-	-	0	0	-	+	+	+
	Bog turtle	-	-	-	0	0	0	+	+	+

The transition of habitat conditions can have varying effects (consequences) for species, depending upon the species' habitat requirements. For example, transitioning from good grassland to an alternative condition, for a species that requires high-quality grassland habitats (*e.g.*, Species A) can have negative population consequences, even if the habitat change is moderate (Table 6). The impacts to species become increasingly apparent as the habitat transitions from good grassland habitat to young forest, with the most severe species effects observed when the habitat transitions to urban or agricultural conditions. Compared to Species A, Species B tolerates shrubs and transitional habitats, but like Species A, cannot adapt to the dramatic alterations found in urban or agricultural conditions. The differential response (*i.e.*, consequences) for Species A and Species B to management options are illustrated in the following example.

Table 6. Consequences table of alternatives for grassland species.

	Grass Good -> Grass Good	Grass Good -> Grass Moderate	Grass Good -> Early Success Good	Grass Good -> Urban/Ag Poor
Species A	0	-1	-1	-2
Species B	0	1	1	-2

Species A: affinity for high-quality grasslands; Species B: tolerant of shrubs & young forests

<u>Step 6: Evaluate trade-offs and optimize decision.</u>

Building on the consequences of changing habitats to the grassland species in the previous example (Table 6), an early prototype illustrates the implications for management decisions (Tables 7, 7a). The actions implemented under either a "protection" or a "management" framework can have implications for both the species and costs. The actions implemented are influenced by several factors including the probability of change in the habitat, probability of a species occurring at the location, the relative "value" of the species, and the relative cost of the action. We describe each component of this prototype more thoroughly below.

Table 7. With the fundamental objective to maximize conservation of Species of Greatest Conservation Need through land protection or management actions (*i.e*., means objectives), initial considerations for evaluating trade-offs and optimizing decisions will include the current state of the system, possible future state (based on threats analysis) and action alternatives with associated cost.

Means Objectives [a]		Current State [b]				Prediction of Possible Future Transitions [c]			Action List [d]	
		Species A Probability	Species B Probability	Habitat type	Habitat quality	Habitat type (+10 years)	Habitat quality (+10 years)	Probability of Conversion	Action Options	Action Cost
No Control	**Protection Problem**	0.3	1	Grass	Good	Urban/Ag	Poor	0.6	None	0
		0.3	1	Grass	Good	Grass	Moderate	0.4	None	
		0.3	1	Grass	Good	Grass	Moderate	1	Buy/ease	$$$
Control or Partial Control	**Management Problem**	0.3	1	Grass	Good	Grass	Moderate	1	None	0
		0.3	1	Grass	Good	Grass	Good	1	Burn	$$
		0.3	1	Grass	Good	Grass	Good	1	Mow	$
		0.3	1	Grass	Good	Early Successional	Good	1	Plant	$$

[a]Means Objectives: Noted as means objectives for Fundamental Objective 1, two options are available for conservation of SGCN, "protection" (*i.e.,* easements or acquisitions) and "management" (*i.e*., enhancement or restoration). Land protection options would be considered for properties not under control of a conservation agency or organization. If management of a property is currently under the control of an agency or organization, management options would be considered.

[b]Current State: The current state is described as the probability of occurrence of a species from 0 to 1 (e.g., Species A = 0.3), the habitat type and its existing condition. In this scenario, the current habitat quality is "good".

- Species A:
  - Requires high-quality grassland habitat
  - Tier 2 species
  - Relative value of 25 (see Table 1)
  - Probability of occurrence is 0.3.
- Species B:
  - Prefers grassland habitat, but is tolerant of shrub and early successional grassland
  - Tier 3 species
  - Relative value of 14 (see Table 1)
  - Probability of occurrence is 1.

[c]Prediction of Possible Future Transitions: This component considers the anticipated habitat type and quality for grassland habitat after 10 years (*i.e*., the State Wildlife Action Plan timeframe). In this scenario, for parcels under easements or acquisitions, (*i.e*., protection), no management action is conducted. However, on managed properties, several best management practices could be implemented. This factor also includes the probability that a parcel will actually transition to the new habitat or cover type (*i.e*., grassland to young forest or grassland to parking lot). For "no action", the probability of conversion differs with the "habitat type + 10 years". The probability of conversion to "urban/ag" = 0.6 and for conversion to moderate "grass" = 0.4. This probability of conversion to 'non-habitat' can be determined through the spatially-linked threats analysis in Step 4. The probability of a habitat converting to a new state contributes to the Action Value of each species (Table 7a) and is discussed later in this document.

[d]Action List: This list contains the management actions and relative cost required to achieve the habitat type and quality in 10 years. For protection, the greatest cost is incurred through easements or purchase of the property. Management actions include "no action", burning, mowing or planting. Each of these actions has inherent costs.

Table 7a. Consequences of alternative actions on Species A and Species B.

	Action List (see Table 7)		**Species A**				**Species B**					
	Action Options	Action Cost	Transition Value to Species A	Action Value to Species A	Difference from "Do Nothing" Species A	Rank Value of Species A	Transition Value to Species B	Action Value to Species B	Difference from "Do Nothing" Species B	Rank Value of Species B	**Value of Action**	**SGCN Value of the location**
Protection	None	0	-2 -1	-1.6	0	25	-2 1	-1.2 0.4	0	14	0	21.5
	Buy/ease	$$$	-1	-1	0.6	25	1	1	1.8	14	29.7	21.5
Management	None	0	-1	-1	0	25	1	1	0	14	0	21.5
	Burn	$$	0	0	1	25	0	0	-1	14	-6.5	21.5
	Mow	$	0	0	1	25	0	0	-1	14	-6.5	21.5
	Plant	$$	-1	-1	0	25	1	1	0	14	0	21.5

Following from Table 7, with alternative actions (*e.g.*, transition from an initial habitat to an altered habitat type) identified, there is need to determine the consequences of the alternative actions for Species A and Species B (Table 7a).

Protection Options:

Parcel: Under the "protection" scenario, management actions (*i.e*., enhancements) are not conducted. The land parcel in this scenario is currently not under any protection or management program.

Possible Future Transitions:

Action Option 1, "no action": The grass habitat transitions to "urban/agriculture" with an associated poor quality condition. For this example, the likelihood of the grassland transitioning to urban/agriculture has been set at 0.6. For this option, there are no actions taken or cost incurred however, Species A and Species B both respond highly negatively (*e.g*., -2) to the new habitat (see Transition Value to Species).

Action Option 2 "no action": The grassland habitat remains as grassland habitat, but the habitat quality declines from good to "moderate" condition. This has a negative consequence for grassland obligate Species A, but Species B has less stringent habitat requirements and is not affected, resulting in action values of -1 and 1.

For these "no action" options, there is no cost, but the Transition Value of the habitat to each species and the probability of habitat conversion contribute to the Action Value of each species.

Option 3 "buy/ease": The grassland habitat remains as grassland, but the quality diminishes over the 10-year period. This option provides for purchase of an easement or fee simple acquisition of the property. Because there is no active management, the change in habitat negatively affects Species A. Species B however, is unaffected by the change in habitat condition and would likely persist on the property.

Habitat Values for SGCN: The value of the protection options to Species A and Species B have been pre-determined by expert opinion (see 'Value to' columns). Under Option 1, the probability of the habitat transitioning to the new condition is less than 1 (*i.e*., 0.6). Because of uncertainty in the transition of habitat from good grassland to urban/agriculture, the relative value to Species A is calculated as the *probability of land conversion * impact to Species A* (0.6*-2 = -1.2), if this conversion occurs. These relative habitat values can be calculated for each species and serve as a measure of the value of habitat change to the SGCN.

Cumulative Value of SGCNs: The SGCN value for a specific parcel can be calculated by multiplying the *SGCN Rank Value * Probability of a species' occurrence*. Then, these values are summed to obtain the value for all species at that location. For example, Species A has 0.3 (probability of occurrence) * 25 (rank value) = 7.5. For Species B, the probability of occurrence is 1.0 * 14 (rank value) = 14 (SGCN Value). Assuming that Species A and Species B are the only SGCN at this location, the total SGCN Value is 21.5 (Table 7a).

Management Options:

Parcel: Under "management" scenarios, actions (*i.e.*, enhancements or best management practices) are conducted to keep the habitat in its current state. In this scenario, the habitat parcel is not currently under any management program.

Action Option 1 "no action": With "no action", the habitat will transition from good to moderate quality with a probability of 1. There is no cost to "no action", but there is a negative consequence for Species A. The Value of Species B is enhanced because it can tolerate a broader range of habitat conditions.

Action Option 2 "burn": If the habitat is managed by burning, there is no effect on the Value of Species A or Species B. The habitat was initially good grassland and remains good grassland.

Action Option 3 "mow": As with Option 2, management by mowing has no effect on the Value of Species A or Species B. The habitat was initially good grassland and remains good grassland. However, cost may need to be taken into account by resource managers. For this scenario, mowing is the less expensive option.

Action Option 4 "planting trees": For a grassland obligate species (Species A), the response to planting trees is negative (-1), but for a more tolerant species (*i.e.*, Species B), there is a positive effect (+1).

Value of Action to Species (Table 7a): The "Value of the Action to Species" can assist resource managers by identifying potential costs or benefits to species from the implementation of specific actions. This calculation is based on:

- Probability of species occurrence (*i.e.*, Species A = 0.3; Species B = 1)
- Difference from a "do nothing" state. This calculation assesses the relative cost of an action when no action is implemented. Example: The "do nothing" value is the cumulative values of "no action". For Species A = (-1.2 + -0.4 = -1.6).

This "do nothing" value provides a foundation for the value of each Action for each Species and will vary by species. So, for the Action option of "buy/lease", the difference from "do nothing" = (Action Value – Value of "Do Nothing") = -1-(-1.6) = 0.6.

- Value (rank) of the Species (*i.e*., Species A = 25; Species = 14)

The Total Value of Action to Species is cumulative for the protection action of "buy/lease" (29.7). In the example, for "protection", relative to a "do nothing" state, the value of action for all species is highest (29.7) when purchasing the property or securing an easement. For "management" options, the outcomes of actions are either neutral or negative. Because Species B has a higher probability of occurrence and can tolerate shrubby grassland habitat compared to Species A, mowing and burning result in a total negative value to species (-6.5). Better options might be allowing natural succession at no cost (*i.e*., take no management action) or planting shrubs at a higher cost.

Relative Costs:

As noted previously, the highest fundamental objective is the conservation of SGCN. Through the process above, the Cumulative Value of Action to Species, (i.e., Species A and Species B) can be calculated and this can guide which actions will achieve the greatest relative benefits for species. Yet, the budget of the resources manager may constrain the actual actions that are to be implemented rather than the overall benefit to species. Some considerations of this assessment would be that:

1. Each management action would be conducted for a parcel and not per species. For example, a parcel wouldn't be repetitively mowed the number of times equivalent to the species present.
2. The activity would have consequences for all species present, with some potentially benefitting and others negatively affected.
3. Funding is limited and the decision is based upon a common potential allocation of funds.

Therefore, one approach could be to assess the Cost per unit of a Conservation Action relative to the Cumulative Value of Action to Species.

From Table 7a, "buying/easements" has a cumulative Value of Action to species of 29.7 whereas the cumulative Value of Action to species for mowing and burning are each -6.5. For this exercise, assume that costs for each activity are as in Table 8.

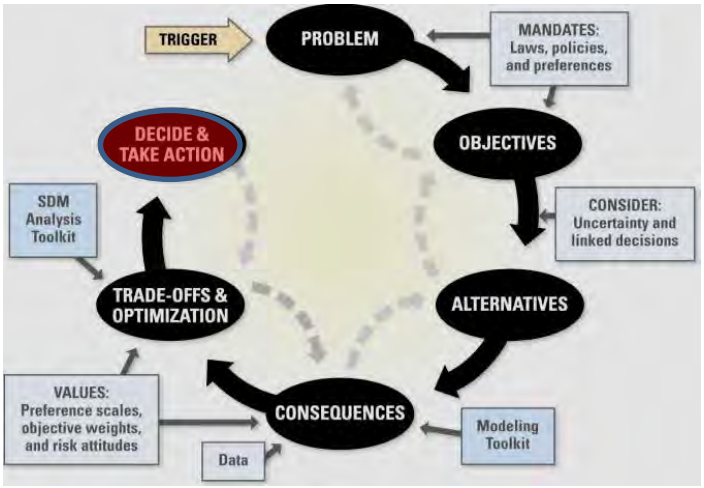
Table 8. Relative costs for management actions.

	Action List (see Table 7)				
	Action Options	Action Cost	**Value of Action to Species**	**Cost/Unit**	**Relative Costs for Management Action**
Protection	None	0	0	0	0
	Buy/ease	$$$	29.7	$1,000	33.67
Management	None	0	0	0	0
	Burn	$$	-6.5	$500	-76.32
	Mow	$	-6.5	$100	-15.38
	Plant	$$	0	$250	0

Thus, based upon this exercise, buying/easements would be the most expensive, yet have the greatest benefit to both Species A and Species B. "No Action" would be the least costly, but would have nominal or no benefits to species. Although burning and mowing have identical Value of Actions to Species (-6.5), the cost of burning is clearly higher than mowing and would thus be the least desirable management action. Given the negative Value of Action to Species, it is likely that neither burning nor mowing would be conducted.

Step 7: Decide & Take Action.

The projected outcomes identified through this process provide a foundation for informing actions that will maximize the conservation value to SGCN. Additionally, this process can serve as a data-evaluation framework to assess costs and benefits of using resources to reduce uncertainties of the system.



This conservation assessment tool will allow a broad range of partners to direct resources towards projects that are most relevant to their resource management interests and financial capacities. It will provide guidance on the priority species and potential actions that may be most beneficial for the specific location.

Uncertainty

The process has highlighted areas in which data gaps will require further attention. Incorporating data into the process is expected to elucidate new data needs and areas of uncertainty. Determining the importance of the uncertainty will guide additional refinement of the data sources.

Uncertainty	Potential approaches
Probability of habitat transition	Literature review; research and monitoring on rate of transitions of various habitat types; spatial analysis.
Probability of species occurrence	Enhanced species distribution models and surveys
Cost of Actions	Gather implementation costs from resource managers for different actions and habitats

Discussion

Value of decision structuring

The Structured Decision Making process allowed a more thorough evaluation of the problem associated with identifying Conservation Opportunity Areas in Pennsylvania. The intensive discussions leading to the decomposition and re-composition of the problem resulted in a

product that is anticipated to be more useful than achieved through prior initiatives. The logical process also provided for increased collaboration and communication, contributing to a well-grounded basis for further development.

Further development required

From the first prototype developed during the workshop, we identified the following next steps:

1. Obtain buy-in from decision makers.
2. Develop a map of SGCN richness based on relative weights of priority tiers and species distribution models with uncertainties. This can be an early product while other components are developed.
3. Spatially link identified threats to species and habitats to understand where these stressors will affect the species across its distribution.
4. Link actions to areas with high SGCN richness. To accomplish this, we must determine transitions from the current state, identify alternative actions, estimate effects of transitions on species, and evaluate consequences in the algorithm. State Wildlife Action Plan Advisory Committee members, agency biologists, and contractors can assist with this aspect.

Prototyping process

Through the workshop, this prototype was the result of significant discussion by the team about the decision problem and means objectives. Our coaches were able to synthesize our key considerations into a modeling framework to facilitate evaluation of trade-offs and consequences. The team was sometimes bogged down in the details; however, the coaches prevented us from "staying in the weeds". We appropriately spent a significant amount of time defining a 'conservation opportunity area', which assisted in ensuring we were addressing the right decision problem. Our team members were conservation partners who play vital roles in implementing actions specified in the State Wildlife Action Plan and their perspectives were critical to framing this problem.

Recommendations

This was an initial pursuit to articulate the decision problem and explicitly state fundamental objectives for illustrating conservation opportunity areas in the revised State Wildlife Action Plan. We will need to review the process and outcomes with primary decision makers in the Pennsylvania Fish and Boat Commission and Pennsylvania Game Commission and revise objectives as needed. We will also review the process and outcomes with additional conservation partners, including those on several State Wildlife Action Plan revision advisory committees. We anticipate refinement of fundamental and means objectives, leading to further development of the prototype.

Literature Cited

Hammond, J.S., R.L. Keeney, and H. Raiffa. 1999. Smart Choices: A Practical Guide to Making Better Life Decisions. Broadway Books, New York.

Appendix: Decision Definitions and Considerations

Species of Greatest Conservation Need (SGCN): This is the focal group of species considered in this decision problem. SGCN are select native species of birds, mammals, fishes, amphibians, reptiles and invertebrates included in the Pennsylvania Wildlife Action Plan due to their global, national, northeast regional, or state rarity, significant threats or declining populations in Pennsylvania. This categorization of species is not regulatory, however federal and state threatened and endangered species are included in this list.

Conservation action: This is the core of the decision problem. A conservation action can be broadly defined as work conducted by state agencies, conservation partners, private landowners, industry and other stakeholders for the benefit of SGCN and their habitats. Conservation actions are linked to current of future threats, and consider climate change impacts as a source of uncertainty. The 2015 SWAP will use a common lexicon to categorize conservation actions (Salafsky *et al*. 2008). Examples of conservation actions include land protection (*i.e*., acquisition, easements, preferred land management practices), habitat improvement and restoration, species reintroduction, land-use planning (*i.e*., ordinances, regulations).

Conservation Opportunity Area (COA): This is what we will term the specific locations identified for conservation action. We can define a COA as a spatially distinct area that supports, or has the potential to support, Species of Greatest Conservation Need (SGCN) and where conservation actions have the potential to improve the future state of the area for SGCN.

Efficient and effective conservation actions: Minimizing costs of conservation actions while maximizing measurable conservation benefits to SGCN and their habitats.

Timing: We consider two timeframes for conservation actions while addressing this problem – the *management timeframe* and the *values timeframe*. With a 10-year planning horizon for the SWAP (2015-2025), the *management timeframe* includes actions that can be accomplished within the next 5-10 years. However, these short-term actions should be directed toward the long-term *values timeframe* of the next 100 years.