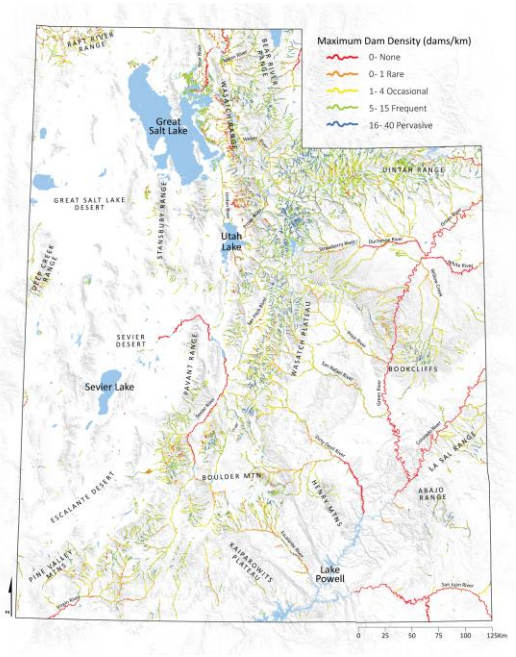
THE UTAH BEAVER RESTORATION ASSESSMENT TOOL:

A DECISION SUPPORT AND PLANNING TOOL

MANAGER BRIEF - UTAH DIVISION OF WILDLIFE RESOURCES



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OCTOBER, 2014

Recommended Citation:

Wheaton J.M. and Macfarlane W.W., 2014. The Utah Beaver Restoration Assessment Tool: A Decision Support and Planning Tool – Manager Brief. Ecogeomorphology and Topographic Analysis Lab, Utah State University, Prepared for Utah Division of Wildlife Resources, Logan, Utah, 16 pp. Available at: http://etal.usu.edu/BRAT/

BACKGROUND

This management brief, presents the key findings from the Macfarlane et al. (2014) The Utah Beaver Restoration Assessment Tool: A Decision Support and Planning Tool report. Beaver dam-building activities lead to a cascade of hydrologic, geomorphic, and ecologic feedbacks that increase stream complexity and benefit aquatic and terrestrial biota. As a result, beaver are increasingly being used as a key component of stream restoration strategies. However, predictive spatial models resolving where within a drainage network beaver dams can be built and sustained are lacking. Moreover, a capacity model approach alone is not enough because many places that beaver might build a dam are in direct conflict with humans (e.g., damming of culverts or irrigation canals and flooding of roads or railroads).

The Beaver Restoration Assessment Tool (BRAT) was developed to fill this void and serves as a decision support and planning tool intended to help resource managers, restoration practitioners, wildlife biologists and researchers assess the potential for beaver as a stream conservation and restoration agent over large regions.

The project described herein improves upon the pilot beaver dam building capacity model, extends the coverage to the entire State of Utah, and develops and tests the decision support and planning components of the tool. The decision support tool accounts for where beaver may pose potential nuisance problems, where 'Living with Beaver' strategies may be needed, where re-colonization and/or reintroduction is most appropriate and identifies potential conservation and restoration areas for beaver. By combining the capacity and decision support approaches, resource managers have the necessary planning information to estimate where and at what level re-introduction of beaver and/or conservation is appropriate.

The four main objectives of the project were to:

1. Complete the development of the BRAT Decision Support and Planning Tool
2. Run BRAT for entire State of Utah
3. Validate BRAT at select target watersheds
4. Synthesize findings from BRAT into recommended adjustments to Utah Beaver Management Plan 2010-2020

This project's primary purpose was to present analyses and a decision support tool to assist UDWR staff in the management of dam-building beaver populations across the state in accordance with the Utah Beaver Management Plan 2010-2020 (UDWR, 2010).

PRIMARY FINDINGS

The Macfarlane et al. (2014) report presented the development and application of the Beaver Restoration Assessment Tool (BRAT), a decision support and planning tool for beaver management, to analyze all perennial rivers and streams in Utah. The backbone to BRAT is a capacity model developed to assess the upper limits of riverscapes to support beaver dam-building activities. Both existing and historic capacity were estimated with readily available spatial datasets to evaluate five key lines of evidence: 1) a perennial water source, 2) availability of dam building materials, 3) ability to build a dam at baseflow, 4) likelihood of dams to withstand a typical flood, and 5) likelihood that stream gradient would limit or completely eliminate dam building by beaver. Fuzzy inference systems were used to combine these lines of evidence while accounting for uncertainty.

The capacity model estimated existing statewide capacity at 226,939 beaver dams (8.3 dams/km) and the historic capacity at 320,658 dams (11.7 dams/km), reflecting a 29% loss of historic capacity (Figure 1). Nearly all of this capacity loss can be explained in terms of vegetation loss and degradation associated with land use: i) urbanization along the Wasatch Front and Cache Valley, ii) conversion of other valley bottoms to agricultural land uses, and iii) overgrazing in upland areas. Despite the losses, the relatively high proportion of publicly owned lands in the state and reasonable condition of many streams in the state mean Utah's watersheds are still capable of supporting and sustaining a substantial amount of beaver dam building activity. Dam capacity was found to be well distributed throughout each of the five Utah Division of Wildlife Resources (UDWR) regions in the state with slightly higher proportional capacity in the Northern and Central regions.

We verified the performance of the existing capacity model using 2,852 existing dams at four watersheds (Figure 2) scattered throughout the state and representing 12.5% of the 27,345 km of perennial streams in the state analyzed. In all four watersheds, model performance was spatially coherent and logical, with electivity indices that effectively segregated out amongst the capacity categories. That is, beaver dams were not found where the model predicted no dams could be supported, beaver exhibited avoidance of reaches predicted as supporting rare or occasional densities, and beaver exhibited preference for areas predicted as having pervasive dam densities. Of the total 1,143 stream segments with validation dam counts only 15 exceeded the capacity estimates indicating that the model effectively segregates the factors controlling beaver dam occurrence and density 99% of the time. These watersheds had average dam densities ranging from 0.1 dams/km to 1.6 dams/km with an average of 0.83 dams/km and roughly 9% of modeled capacity. We found that validation watersheds in the northern portion of the state were currently at a higher percentage of capacity than watersheds in the southern portion. The Logan/Little Bear watershed (Northern Region) is currently 16% of capacity and

Strawberry watershed (Northeastern Region) is 13% whereas the Fremont watershed (Southern and Southeastern regions) and Price watershed (Central and Southeastern regions) are currently both only 1% of existing capacity. If these validation watersheds are in fact representative of statewide trends then dam building beaver populations across the state are only at a small fraction of the actual capacity and are much lower in the southern portion of the state than in the northern.

To make some rough estimates of beaver dam numbers for the state, we extrapolated our findings from the verification watersheds using the capacity model. We determined the full range of percent of capacity estimates realized by capacity prediction categories, which ranged from 1 to 38% with an average of 8%. Using a variety of estimates, we estimate there are somewhere around 20,000 beaver dams currently in the state, but it is plausible the number is as high as 40,000. Either way, the State of Utah's rivers and streams are currently well below the capacity of these streams to support beaver dams (8% to 17% of capacity). Given that beaver have not been actively promoted or encouraged in most parts of the state, and in many parts they are actively removed, it is likely that historically (pre-European settlement) the realized percent of capacity was much higher (likely 30% to 50%).

The decision support and planning tool side of BRAT uses simple geospatial analysis and rule systems to account for the recovery potential of riparian habitat and human conflict (Figure 1C) with beaver dam building to segregate the stream network into various conservation and restoration zones (Figure 1D). BRAT categorized 35% of the state as 'Low-hanging Fruit' streams signifying habitats that are either currently inhabited by beaver or are in relatively good condition for beaver re-colonization and/or reintroduction. Another 29% of the state was identified as 'Living with Beaver' signifying areas that could benefit from 'Living with Beaver' strategies.

We believe the spatially explicit outputs from BRAT provides UDWR biologists with the information needed to effectively identify where nuisance beaver can be relocated, where 'Living with Beaver' strategies may be needed and where beaver can be used for watershed restoration efforts to have the greatest potential to yield increases in biodiversity and ecosystem services. Not only does this help with broad-scale planning efforts, but the resolution is sufficient (Figure 3) to support detailed design and on the ground implementation of translocation and restoration activities.

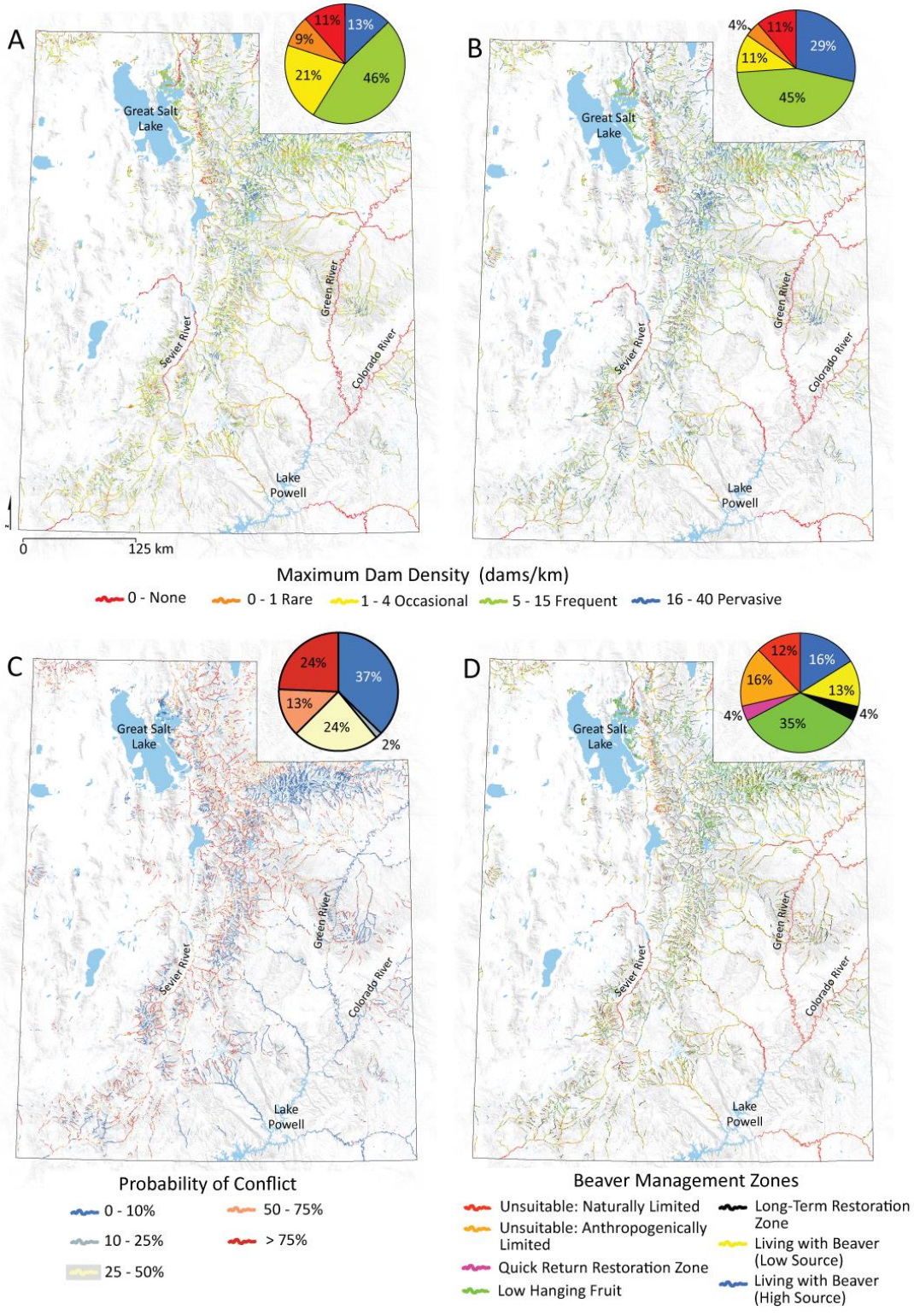

Figure 1 – Map of statewide BRAT outputs that includes A. existing beaver dam capacity, B. historic beaver dam capacity, C. probability of potential conflict, and D. beaver conservation and restoration zones (i.e., Beaver Management Zones).

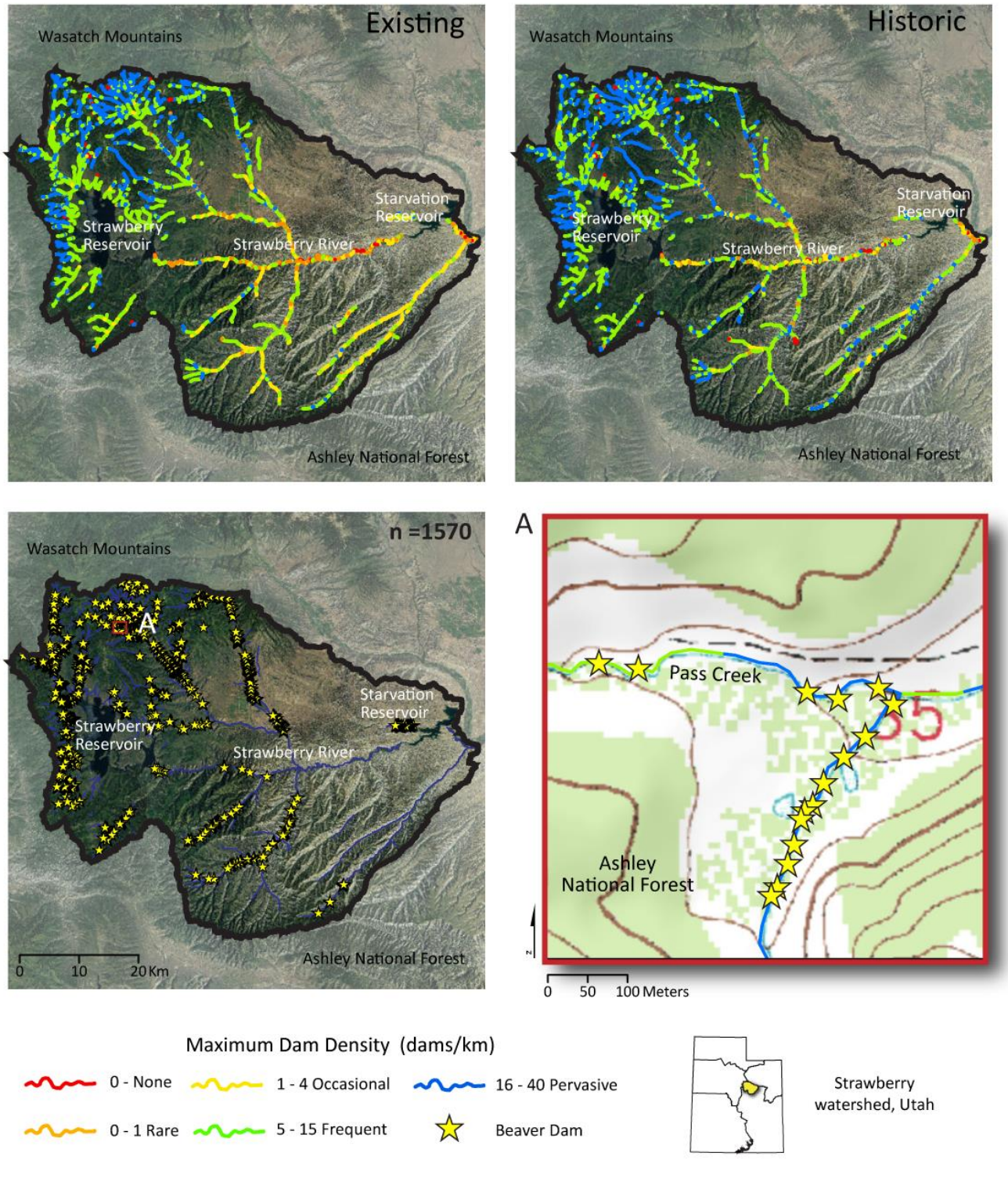

Figure 2 – Example map from (Macfarlane et al., 2014) of validation data (actual beaver dam locations) for the Strawberry watershed with existing capacity estimates, historic capacity estimates, and actual beaver dam counts.

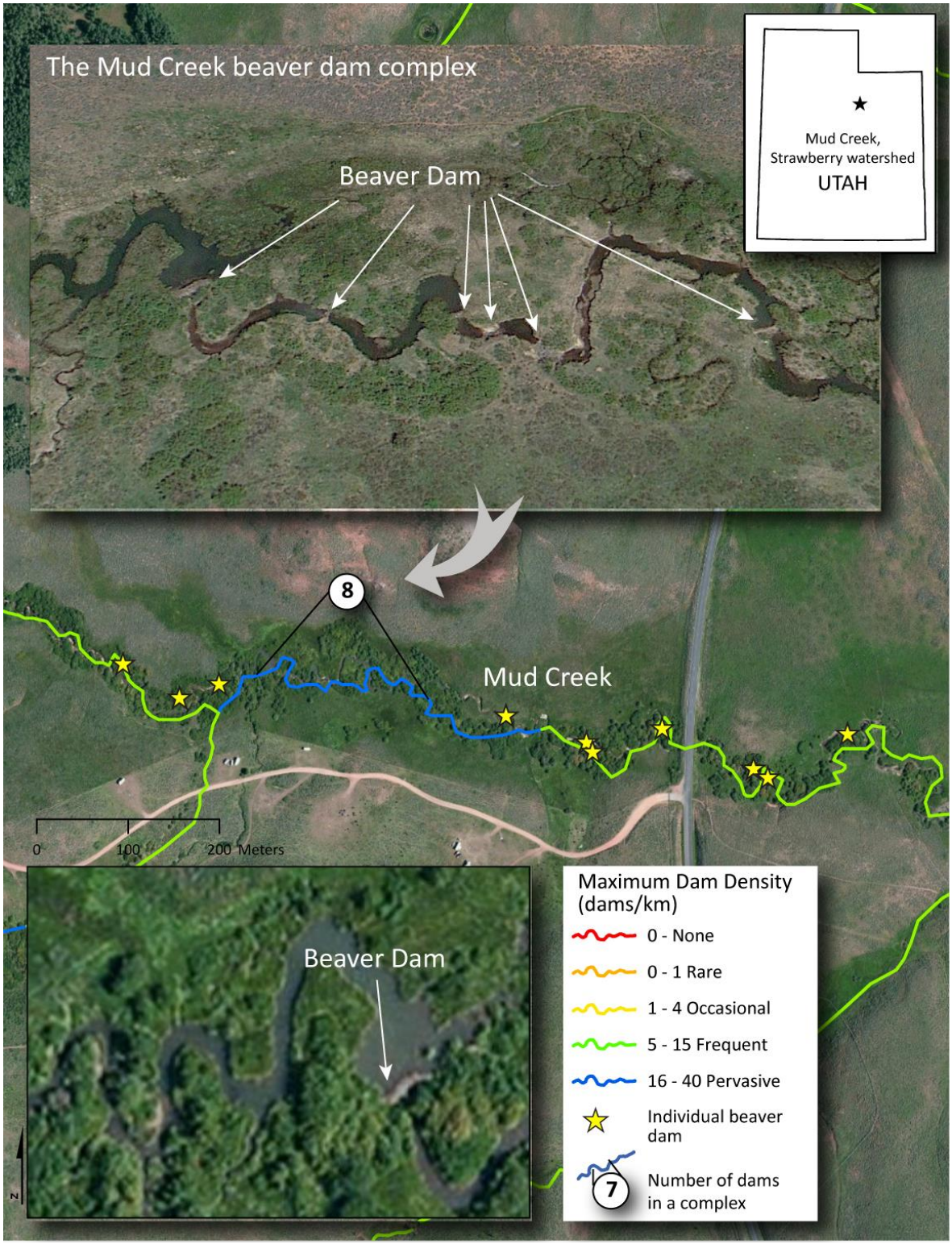

Figure 3 – Example of resolution of beaver dam capacity model (250 m segment resolution) on Mud Creek. This resolution now exists for every stream and river in the State of Utah. Individual beaver dams are denoted with yellow stars, whereas, dam complexes are shown in circles (number in circle is count of dams) in discrete segments. The figure illustrates how the model has effectively differentiated pervasive and frequent dam densities reaches.

RECOMMENDATIONS FOR THE UTAH BEAVER MANAGEMENT PLAN

The UDWR has one of the most progressive statewide beaver management plans (UDWR, 2010) in the country. This plan paves the way for a more holistic and sustainable approach to beaver management. However, to date, too few examples exist of the plan being implemented on the ground by UDWR personnel and partners as intended, despite large interest amongst a diverse group of organizations and individuals. We believe this is the case in part because although the plan lays out clear policies, goals and strategies; the specifics of how to implement specific strategies on the on the ground are lacking. Actively relocating nuisance beaver to parts of watersheds and the state in which they could be restoration agents is relatively new territory for UDWR staff. Demonstration projects are underway to help provide such guidance (e.g. Watershed Restoration Initiative & Sage Grouse Initiative Funding in Raft River Basin; translocation in Uintah Basin). However, we have tailored the BRAT to specifically help UDWR implement the plan. In the Macfarlane et al. (2014) report we provide detailed suggestions on how BRAT can specifically help UDWR staff implement the strategies. In other instances, we made specific recommendations to update the plan. A brief summary of bullet recommendations is provided below by topic:

- **Population Management**
  - Extend the Google Earth-based beaver dam census statewide used in Macfarlane et al. (2014) report to verify model performance.
  - Update the Beaver Management Plan with new maps from the outputs of BRAT.
  - Use 'Beaver Monitoring App' to track dams and infer population numbers. In partnership with Utah State University's Water Quality Extension's 'Utah Water Watch' program, we developed an app for citizen science monitoring of beaver, beaver dams and beaver activity (http://extension.usu.edu/utahwaterwatch/htm/beaver-monitoring-app). The program could coordinate volunteer efforts to target 'missing' parts of the state where we need to know more. The app could also be deployed with UDWR personnel so they could track their observations. We could extend the app to meet UDWR's specific needs and share the database with UDWR.
  - Leverage data collection on beaver from other agencies.
  - Replace the 'baseline map' with BRAT outputs.
- **Harvest Management**
  - Using BRAT to encourage the growth of beaver populations in areas with low conflict potential and high capacity to support beaver could potentially increase this important recreational fur-trapping resource.

- Through time, we recommend that UDWR work with groups using beaver to restore streams and rivers to limit trapping in areas where beaver are translocated until such time that the restoration benefits have been realized and beaver populations are at a level they can support a sustainable harvest.
- More research is needed to ascertain what defines a 'sustainable' harvest.

- **Damage Management**
  - We recommend that UDWR develop an 'Adaptive Beaver Management Plan' that spells out specific 'standard' responses and workflows to nuisance damage situations and give UDWR staff a workflow to fall back on. We developed such a plan for Park City Municipal Corporation (Wheaton, 2013). The key workflows of the adaptive management plan are highlighted in two flowcharts (Figure 4 and Figure 5), which could be easily adapted by UDWR to represent their circumstances. The core of the adaptive management plan is an adaptive management loop that starts with planning, proceeds through actions ('do'), and evaluation and learning, that either feedback periodically on planning or can be used to adjust actions. The importance of casting the damage management through the lens of an adaptive management plan is it transparently articulates a course of action to follow based on the best available information, but affords UDWR the flexibility to adapt that plan through time as more is learned and situations arise that may not have been anticipated.

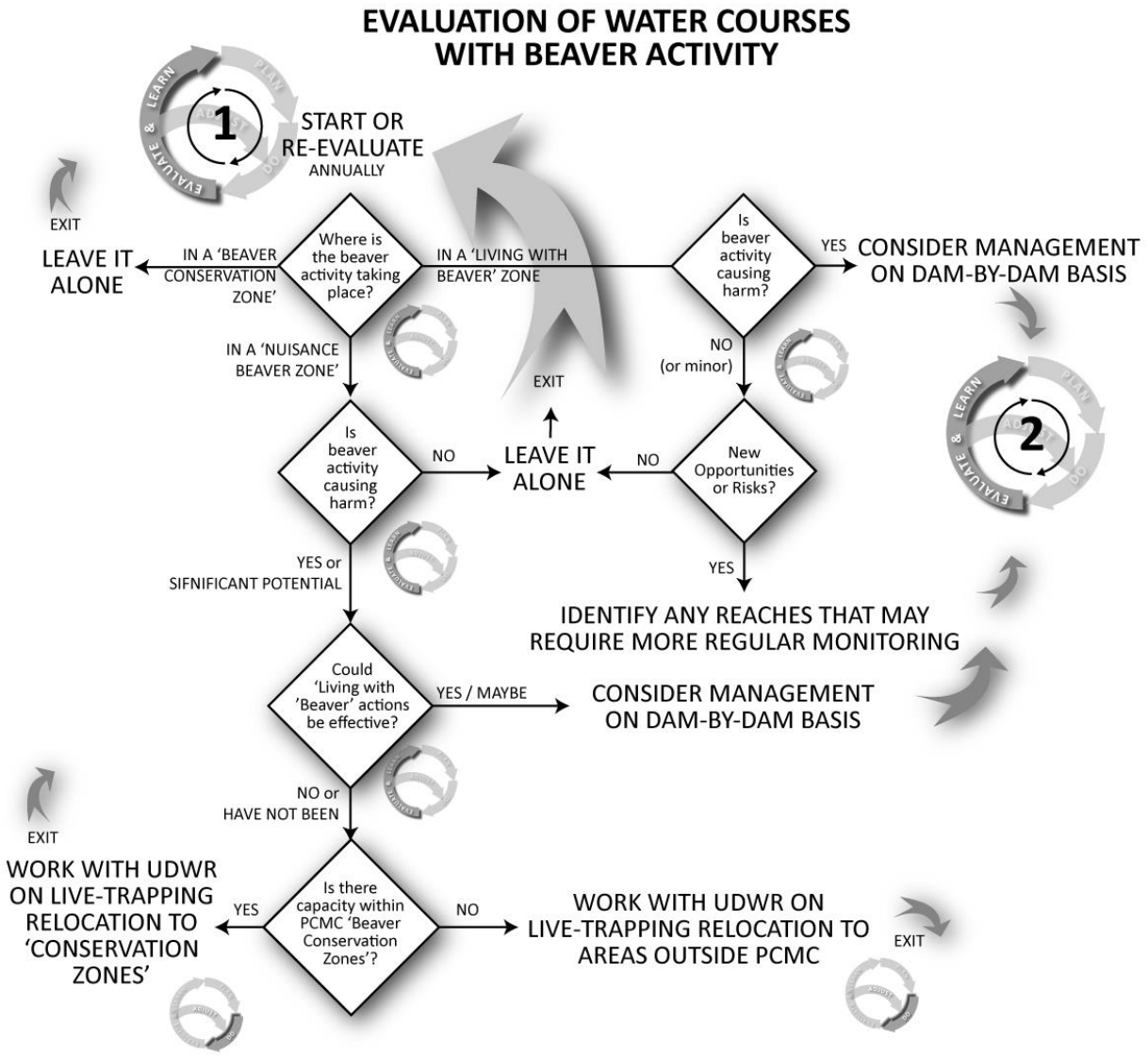

Figure 4 – Example of key component of an 'adaptive beaver management' plan for evaluating potential 'nuisance beaver activity' on water courses mapped as 'Living with Beaver' zones. Figure from Wheaton (2013) developed for Park City Municipal Corporation (PCMC), but could be adapted for UDWR purposes.

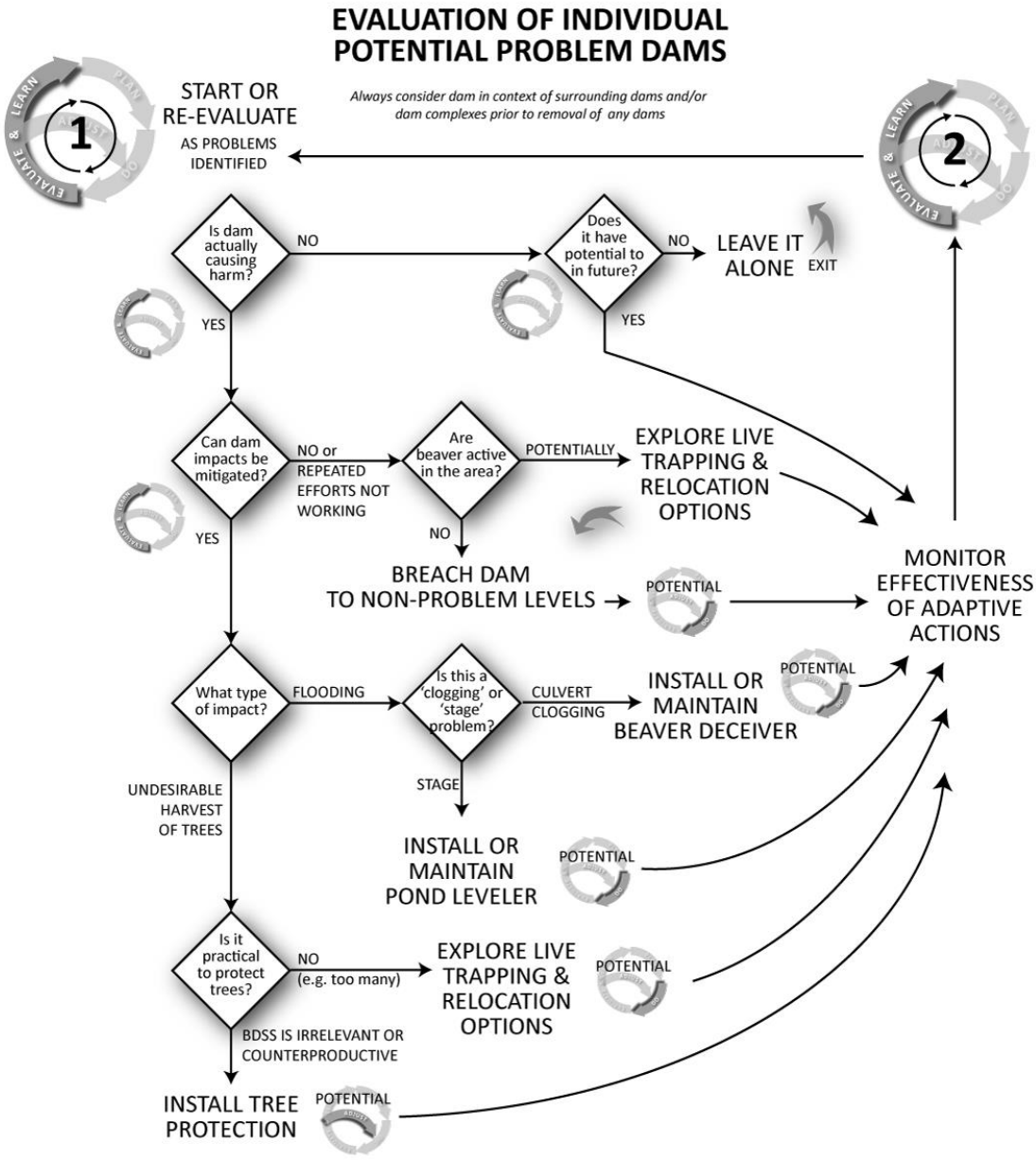

Figure 5 - Example of key component of an 'adaptive beaver management' plan for evaluating potential 'nuisance beaver activity' on water courses mapped as 'Living with Beaver' zones. Figure from Wheaton (2013) developed for Park City Municipal Corporation (PCMC), but could be adapted for UDWR purposes.

- **Statewide Beaver Transplant List**
    - We recommend that the transplant list is either replaced or updated to include streams designated by BRAT as 'Low-hanging Fruit Restoration Zone' and 'Quick Return Restoration Zone' that are also suitable for beaver transplant and should be added to this list as candidate streams.
    - We recommend that the Regional Prioritization/Ranking is removed or made more transparent.
- **Watershed Restoration**
    - We recommend that the BRAT capacity model is used to identify 'suitable habitat' and that the human-beaver conflict potential model identifies areas of low risk of creating damage conflicts.
- **Live Trapping Protocol**
    - We believe that the COR program and training mentioned in §1.a.i of the Protocol, is desperately needed to certify trappers (private or with other agencies) to allow them to implement the intent of the Beaver Management Plan.
    - We recommend developing a simple app and web-reporting system to allow UDWR to track and monitor all translocation activities to help inform population management decisions and future policy.
    - We believe that the habitat assessment section (§ 2.a) is inadequate and should be updated based on BRAT.
    - The language surrounding 'source population considerations' is unnecessarily restrictive. We suggest the wording should be relaxed (similar to §2.c.ii) to allow flexibility: e.g. "Translocated beaver should generally be targeted within the same 2 digit Hydrologic Unit Code (in or outside State of Utah) to account for unique characteristics.

FUTURE WORK

With the completion of the statewide run of BRAT the decision support and planning tool is now complete. The next steps are to i) continue to verify and refine the performance of BRAT ii) and make BRAT more useful to managers, practitioners and researchers. Some of the most important future BRAT developments from a management perspective are highlighted below.

HYDROLOGIC IMPACTS

Ultimately the capacity models could and should be used to support scenario development of different densities and combined with hydrologic modeling efforts that attempt to quantify and

explore the impact of beaver dam building on water resources. It is highly likely that if many of Utah's 1st, 2nd and 3rd order streams realized even 15% to 25% of their current capacities, there would be major impacts on water resources. Since beaver dams slow the runoff of water, they promote significant contributions to local groundwater tables and expansion of riparian vegetation. It is possible that this slowing of water delivery could result in a minor net loss of water from the system over the season through direct evaporation and evapotranspiration from expanded riparian vegetation areas associated with beaver dams. However, normally, a similar or greater volume of water would leave the system as spring runoff at a time it cannot be fully utilized downstream (e.g. storage capacity of many man-made reservoirs is only so much, and irrigation demands in late spring are generally small) and is therefore 'lost' anyway. We hypothesize that the total seasonal runoff volume impacts will be inconsistent (some gains, some losses) and insignificant compared to the timing impacts. Specifically, since many beaver dams in a system act to create a sponge (inclusive of small storage capacity in beaver dams, and larger storage capacity in alluvial fills of small valley bottoms), we expect beaver dams to slowly release the water out over the summer and early fall at a time when downstream riparian areas and water users need it most. We speculate that in many watersheds, these gains may be enough to compete with lost storage capacity from a declining snowpack. We recommend more research is done to better establish the empirical relationships between beaver dams and their local hydrologic impacts, and build the hydrologic modeling framework to represent those changes in runoff and delivery as impacted by beaver dams.

CONFLICT POTENTIAL MODEL REFINEMENTS

We are confident we have captured appropriate input data to adequately reflect potential conflict with humans. However, the actually probabilities likely need to be adjusted to more accurately reflect stakeholder desires and concerns. Some places, landowners and managers may have higher tolerances and appetite for 'living with beaver' strategies; whereas, others may simply want beaver removed. In general, there is no permanent solution to 'nuisance' beaver problems and all lethal and non-lethal means represent short term mitigations best viewed as maintenance. All the same, the conflict potential model could be adjusted based on recommendations from UDWR staff gained from interactions and feedback from various stakeholders.

BEAVER MANAGEMENT, RESTORATION AND CONSERVATION MODEL REFINEMENTS

The next round of BRAT development should focus on partnering with UDWR staff and other land and resource managers to improve the outputs of the 'Preliminary Statewide Beaver Management, Restoration and Conservation' model output (Figure 1D). This would be done by tweaking the underlying inputs and logic of the management model. Combining the actual dam

counts with the existing models, we could identify source and sink zones throughout the state. Thus indentifying where beaver could be relocated or vegetation restoration projects could be implemented based on where beaver are and instead of just where they could be.

FUTURE BRAT TOOLS

We think we could make BRAT more useful to managers, practitioners and researchers if we could deploy it as:

- A WebGIS application that would allow users to:
    - Explore and visualize a Base-Version of BRAT run for the Western US in a Google Maps interface
    - Run and produce simple BRAT scenarios where user can control parameters:
        - Toggle thresholds and transform functions for the probabilistic Human-Beaver Conflict Potential output
        - Toggle thresholds and adjust logic
    - Export their own BRAT outputs as KML or shapefiles
- An ArcGIS Plugin or Add-In that would allow users to:
    - Download and modify Base-Version of BRAT for area of interest
    - Run and produce BRAT scenarios based on customized user inputs (e.g. higher resolution maps)

ACKNOWLEDGEMENTS

This work is funded by the Utah Division of Natural Resources (USU Award No. 130940). We wish to thank John Shivik (formerly UDWR) who made this project possible and secured the funding to support it. The development of the BRAT model benefitted greatly from insights and conversations with Mary O'Brien (Grand Canyon Trust), John Shivik (USFS – formerly UDWR), Nick Bouwes (Eco Logical Research), Chris Jordan (NOAA), Nate Hough-Snee (USU), Ryan Lokteff (USU), Michael Pollock (NOAA), Brett Roper (USFS), John Stella (SUNY) and Kent Sorenson (UDWR). Jordan Gilbert, Jordan Burningham and Chris Smith provided much appreciated GIS support for this project.

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