**Supplemental Materials**

**Institutional Diversity in the Planning Process Yields Similar Outcomes for Vegetation in Ecological Restoration**

Contents

[Social Science Data and Analysis Supplemental Information 2](#_Toc16597697)

[Supplemental Table 1. Number of respondents, interviews, other conversations, site visits, and meetings 2](#_Toc16597698)

[Supplemental Table 2. All qualitative codes 3](#_Toc16597699)

[Supplemental Table 3. The components of the ADICO syntax and how they define rules, norms, and strategies. 4](#_Toc16597700)

[Supplementary Table 4. Examples of levels of analysis for Institutional Statements. 5](#_Toc16597701)

[Supplementary Table 5. Data Template for Institutional Statements, with Examples 6](#_Toc16597702)

[Social Science Variables Used in the Integrated Analysis 7](#_Toc16597703)

[Matrix analysis 13](#_Toc16597704)

[Supplemental Table 6. Values for each social science variable used in the integrated analysis. 14](#_Toc16597705)

[Vegetation Data 15](#_Toc16597706)

[Correcting for Sampling Effort 15](#_Toc16597707)

[Distance Measures Used in the Multivariate Analyses 15](#_Toc16597708)

# Social Science Data and Analysis Supplemental Information

Supplemental Table 1. Number of respondents, interviews, other conversations, site visits, and meetings (summed for a total number of field notes for each case)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  **Site:**  | **R1** | **R2** | **C1** | **C2** | **C4** | **C1-4** | **M1, M5** | **M2** | **M3** | **C3** | **M4** | **Total** |
| Number of respondents | 4 | 9 | 3 | 3 | 6 | 13 | 9 | 15 | 6 | 3 | 5 | 76 |
| Number of interviews | 4 | 10 | 2 | 3 | 7 | 13 | 11 | 15 | 4 | 2 | 9 | 80 |
| Number of other conversations | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | 0 | 2 | 14 |
| Number of site visits | 2 | 1 | 2 | 3 | 6 | 0 | 5 | 3 | 2 | 4 | 4 | 32 |
| Number of meeting observations | 0 | 1 | 6 | 2 | 1 | 5 | 3 | 3 | 2 | 3 | 2 | 28 |
| Total field notes per case | 7 | 13 | 13 | 9 | 15 | 19 | 20 | 23 | 9 | 9 | 17 | 154 |

Note that C2, C3, and C4 have an additional column in which data were collected from the land owning agency (C1-4). Because the land owning agency data concern all three of the sites, we kept these data separate in this table. C3 and M4 are the two replicate cases (in which data collection was delayed until data from the first cases were analyzed).

Supplemental Table 2. All qualitative codes (tree nodes and free nodes) used in the analysis of interview and participant observation data. Tree Nodes put concepts in a hierarchical arrangement. Free Nodes do not.

**TREE NODES**

**Actors**

Scientists

Volunteers

stewards

Staff

administration

project manager

planners

superiors

co-workers

president

Board

Committees

Public

partners

constituents

children

community

neighbors

**Management Actions**

Fire

brush piles

Seeds

Removal

mowing

cutting

herbicide

Monitoring and inventorying

Management plan

Soil

Water

Disturbance control

trash pick-up

Other

**Decision Information**

Communication

requests

meetings

Group process

Justification/criteria

minimize harm,

data,

management perspective

**Perception of Landscape**

Involvement

Inappropriate

Proximity

Green Infrastructure

Non-native

Sense of ownership

Size and scale

Sustainability

Natives

Authenticity

Social-cultural

Stewardship

Participation

Clean

Listening to Nature

Constraints

Privacy screen

Safety

Balance

Differing perceptions

Children’s engagement

Use

Social acceptability

Scenic vs. ecol. beauty

Quality of phys. environment

Protection vs. use

Place identity

Perceptual categorization

Perceptions of place

Perception of change

Noticeability

Natives vs. exotics

Multisensory perception

Motivations

Invasives

Habitat suitability

Functionality

Experience

Engagement

Ecological knowledge

Ecological aesthetic

Description

Deep values

Cues to care

Connecting with nature

Aesthetics

**Emotion**

Negative emotions

insecurity

polarization/conflict

disappointed

fear/anxiety

disgust

hurt

frustrated

angry

sad/lament/regret

distress

Positive emotions

pride

appreciative

amazed/awe/wonder

happy/enjoy/fun/pleased

trust

Other

surprise

sarcasm

excited

concern/care

**Animals**

Fish

Beaver

Coyotes

Herps

Birds

Deer

Dogs

Insects

Other mammals

**Resources**

Information

Equipment

Labor

seasonals

contractors

interns

Money

donations

taxes and bonds

grants

**FREE NODES**

Restoration philosophy

Workdays

Goals

Weather and season

Research

Time

History of organization

Sensitive information

Support

Outreach and education Conflict

## Supplemental Table 3. The components of the ADICO syntax and how they define rules, norms, and strategies.

|  |  |
| --- | --- |
| **Component** | **Definition** |
| ***A*** | Attribute (the “who”- who does this statement refer to?) |
| ***D*** | Deontic (may, must, must not, should, should not) |
| ***I*** | aIm (the “what”- what is the statement about?) |
| ***C*** | Condition (under what conditions must the aIm occur?) \*Default can be “in all times and in all places.” Ostrom 2005: 149 |
| ***O*** | Or Else (sanction for not following a rule, norm, or strategy)\*The term “or else” is only used for rules.\* Can be gradual- initial or accidental violations may not incur tangible sanctions, but repeated violations lead to them. Ostrom 2005: 152; 2012 |
|  ***ADICO*** = Rule ***ADIC*** = Norm ***AIC*** = Strategy |
| **RULE1:** All villagers [**A**ttribute] must not [**D**eontic] let their animals trample [a**I**m] the irrigation channels [**C**ondition, note that the animals *may* trample elsewhere and not trigger this rule] or else the villager who owns the livestock will have to pay a fine [**O**r else].” |
| **NORM:** If you [**A**ttribute] use the microwave [**C**ondition], you must [**D**eontic] clean up your own mess [a**I**m]! |
| **STRATEGY:** The person who places a phone call [**A**ttribute] calls back [a**I**m] when the call gets disconnected [**C**ondition]. |

**1** Rule, norm and strategy examples are from Ostrom, *Understanding Institutional Diversity*, 2005, p. 139.

## Supplementary Table 4. Examples of levels of analysis for Institutional Statements.

|  |  |  |
| --- | --- | --- |
| **Level** | **Definition** | **Example** |
| Constitutional | Prescribing, invoking, monitoring, applying, enforcing (e.g. an organizational policy that forbids discrimination). | A state-level policy maker, or an organization board member, establishes regulations and guidelines for natural resource management decision processes, and decides who can be involved in those processes. |
| Collective-choice | Prescribing, invoking, monitoring, applying, enforcing (e.g. a group of employees conducting an interview or hiring a person) | Staff of an organization are allowed to determine which management techniques should be used, or criteria (who, where, how) for their use. |
| Operational | Provision, production, distribution, appropriation, assignment, consumption (e.g. an employee conducting his/her assignment) | Staff or volunteers of an organization are allowed to implement particular management techniques on the ground. |

## Supplementary Table 5. Data Template for Institutional Statements, with Examples

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Case | Who | Statement | **A**ttribute | **D**eontic | a**I**m | **C**onditions | **O**r Else | Level\* | Class\*\* | Type\*\*\* | Notes |
| M7 | MN | Staff must not talk with board without permission – could be fired | Staff | must not | talk to board members | ever, w/o approval | risk los-ing job | O | I | R | “Unless I get permission, I’m not supposed to talk with board members” – several mentioned this. |
| M2 | TU | Ecologists should go to [staff member X] with restoration questions because she is experienced. | Ecologists | should | go to X with restoration questions | always |  | O | I | N | This staff member is respected and trusted (positive emotions) |
| R2 | AB | Manager may collect seed locally | Org. restoration staff |  | collect seed | Locally (own site, up to 200 miles) |  | O | C | S | Collects mostly from own site |

\* O = operational C = Collective Choice. \*\* Classification of Institutional Statement: **P**osition statement, **B**oundary statement, **I**nformation statement, **P**ayoff statements, **A**ggregation statements, **C**hoice statements, and **S**cope statements. \*\*\* **R**ule, **S**trategy or **N**orm.

## Social Science Variables Used in the Integrated Analysis

The following describes each variable developed for the integrated analysis, including the variable name [in brackets] and its descriptive name, the values, the definition and the cases for each category. Additional detail, including example data excerpts from interviews and field notes that support relevant categories, can be found in [Removed for blind review]. In order to strengthen the ecological data, that team collected data from three additional sites that were managed by the same restoration decision makers as other sites where the social science team collected in-depth data. However, interviews, meeting observations, and site visits were not conducted at these three additional sites. Because of the overlapping management, we were able to infer social science data from their referent site. For example, the group size and decision-making processes were the same for the sites where the additional ecological plots were measured. In these instances, we used the values from the referent social science site in the matrix. Variables # 13, 14, 26, and 27 are exceptions where using the values of the referent site was not justifiable. We detail the adjustments we made for those variables below (see also Supplemental Table 6; additional detail in [Removed for blind review]).

For variables where judgment was needed (e.g., group size), the categories and categorization of sites was determined by two of the lead social scientists, then presented for discussion and review to the entire seven-member social science team. A consensus was reached, and is in the tables below.

**1. [time] Length of restoration:** A continuous variable of how long restoration has been taking place at the site. See Supplemental Table 6 for the length of restoration for each case.

**2. [groupsize]** **Group size, as it relates to input into restoration decisions:** We created this ranked ordinal variable based on approximately how many people are involved (with broad estimations of the weight of their input) with collective-level decisions for that site.

|  |  |  |
| --- | --- | --- |
| **Value** | **Definition** | **Cases** |
| 1 | Small (2-7 people with input) | R1, R2, C4, M3, M4 |
| 2 | Medium (8-16 people with input) | C2, M1, M2 |
| 3 | Large (17+ people with input) | C1, C3  |

**3. [board] Role of Board in restoration decisions:** This ranked ordinal variable describes the role of the Board in restoration decisions.

|  |  |  |
| --- | --- | --- |
| **Value** | **Definition** | **Cases** |
| 1 | Minor role | R1, R2, M4, C4 |
| 2 | Irregular but important role | M1, M2, C1, C2, C3 |
| 3 | Regular and important role | M3 |

**4. [publland] Public land:** A dichotomous categorical measure of whether the land is publicly owned.

|  |  |  |
| --- | --- | --- |
| **Value** | **Definition** | **Cases** |
| 0 | Not public | M3, R2 |
| 1 | Public land | C1, C2, C3, C4, M1, M2, M4, R1 |

**5. [mtgstyle] Meeting style:** This ranked ordinal variable is a qualitative assessment based on interview and observation data about the regularity of formal group meetings and their impact on ecological restoration decisions.

|  |  |  |
| --- | --- | --- |
| **Value** | **Definition** | **Cases** |
| 1 | Low impact | C2, C4 |
| 2 | Low-medium impact | M2 |
| 3 | Medium impact | R1, M4  |
| 4 | Medium-high impact | R2 |
| 5 | High Impact  | C1, C3, M1, M3 |

**6. [dmstyle] decision-making style:** This ranked ordinal variable describes the complexity, clarity, and functional capacity of the decision-making process. This composite variable is a qualitative assessment and includes factors like the number of subgroups, and respondents’ perception of complexity, clarity, and functionality of the process.

|  |  |  |
| --- | --- | --- |
| **Value** | **Definition** | **Cases** |
| 1 | Simple, typically one decision maker | C4, R2  |
| 2 | Simple, multiple decision makers | M1, M4 |
| 3 | Complex, multiple decision makers | M2, M3, R1, C2 |
| 4 | Very complex (multiple, semi-autonomous groups having their own decision-making systems, and also trying to work together) | C1, C3  |

**7. [difview] Differing views:** This ranked ordinal variable captures an organization’s ability to acknowledge and handle differing views about restoration actions, which can reduce the likelihood of conflict. The variable is a qualitative assessment of group members’ willingness to accept differing views of others in the decision-making process (views outside the decision-making process are taken into account in the variable [public], below).

|  |  |  |
| --- | --- | --- |
| **Value** | **Definition** | **Cases** |
| 1 | Very willing to acknowledge and work with differing views, with ways of circumventing problems via leadership and key positions | M1, M2 |
| 2 | Willing (little evidence of differing views) | R2 |
| 3 | Somewhat willing | C4, M3, M4, R1  |
| 4 | Not very willing  | C2 |
| 5 | Very unwilling  | C1, C3 |

**8. [volauton] Volunteer autonomy:** This ranked ordinal variable measures volunteer’s ability to cross over from the community to the action arena in the IAD (Fig. 2). Autonomy is indicated in part by the kinds of activities volunteers are permitted to do and levels of supervision of their work.

|  |  |  |
| --- | --- | --- |
| **Value** | **Definition** | **Cases** |
| 1 | Low (Volunteers are supervised by a staff member while working on a site; they assist but do not lead any restoration workdays on their own) | M3, M4, R1 |
| 2 | Medium (Trained volunteer stewards may hold and supervise workdays on designated sites/areas, but they may not burn brush piles or use chain saws)  | M1, M2, R2 |
| 3 | Medium-high (Trained stewards may burn brush piles and use chainsaws) | C1, C2, C3 |
| 4 | High (Trained volunteers may burn brush piles, use chainsaws, and conduct prescribed fires.) | C4 |

**9. [research] Extent of research:** This ranked ordinal variable is a qualitative assessment of extent of research activities occurring at the site.

|  |  |  |
| --- | --- | --- |
| **Value** | **Definition** | **Case** |
| 1 | None | C2 |
| 2 | Some monitoring and data collection | C1, C3, C4, M3, M4 |
| 3 | Monitoring and some research and/or experimentation | M1, M2, R2 |
| 4 | Monitoring and lots of research and experimentation | R1 |

**10. [public] Concern regarding potential public response:** This ranked ordinal is a qualitative assessment of the extent to which the organization is sensitive to, or concerned about, potential public reaction to restoration (it includes assessment of the following codes: social acceptability, noticeability, proximity, privacy screening).

|  |  |  |
| --- | --- | --- |
| **Value** | **Definition** | **Cases** |
| 1 | Less concerned about negative reaction from public  | C2, C3 |
| 2 | Some concern | C4, M4, R2  |
| 3 | Moderately concerned | M1, M2 |
| 4 | Very concerned | C1 |
| 5 | Extremely concerned | M3, R1 |

**11. [membership] Membership:** This variable is a dichotomous categorical measure of whether there are paying members or not.

|  |  |  |
| --- | --- | --- |
| **Value** | **Definition** | **Cases** |
| 0 | No | C1, C2, C3, M1, M2, M4 |
| 1 | Yes | C4, M3, R1, R2  |

**12-14. [overemo, posemo, negemo] Emotion:** These variables represent a fundamental component of human behavior known to impact decision making and more (see Table 3 and see Supplemental Table 6 for the emotion values for each case; details about adjustments for the cases where inference was necessary are in [Removed for blind review]).

**12. [overemo] Overall emotion**:  Each case has a total number of references coded to an emotion. For each site, we divided the total number of emotion codes by the total number of emotion references for *all* sites to get a proportion of emotion for that site (relative to other sites).

**13. [negemo] Negative emotion:** Each case has a total number of references coded to a negative emotion. For each case, we added all of these up (total # for fear + total # for angry + etc.) and divided it by the total number of negative emotion references for *all* cases to get a proportion of negative emotion for that case (relative to other cases).

**14. [posemo] Positive emotion:** Each case has a total number of references coded to a positive emotion. For each case, we added all of these up (total # for happy + total # for pride + etc.) and divided it by the total number of positive emotion references for *all* cases to get a proportion of positive emotion for that case (relative to other cases).

**15-20. [numbrule, numbnorm, numbstrat, numbaggr, numbcol, numboper] Suite of institutional statements:** These continuous variables are raw scores of the types of institutional statements used (rule, norms, and strategies) and the overall institutional complexity (in terms of the number of statements).; see Supplemental Table 6 for the institutional variable values for each case). Aggregation statements indicate the degree to which decision making is shared across various actors. Operational and collective level institutional statements also indicate the type of decision making in effect (there were very few constitutional level institutional statements in our data).

**15. [numbrule] Number of rules:** The total number of rules documented for the case.

**16. [numbnorm] Number of norms:** The total number of norms documented for the case.

**17. [numbstrat] Number of strategies:** The total number of strategies documented for the case.

**18. [numbaggr] Number of aggregation statements:** The total number of aggregation statements for the case.

**19. [numbcol] Number of collective level statements:** The total number of collective level statements for the case.

**20. [numboper] Number of operational level statements:** The total number of operational level statements for the case.

**21-23. [seedcoll, seedpurch, seeddist]** **Seeding:** Only one restoration activity showed much variance across sites: seeding. These variables capture these differences in seed collecting, seed purchasing, and the distance from which seed was allowed to be used (fire, use of herbicides, etc., are relatively constant across cases).

**21. [seedcoll] Seed collect:** This ranked ordinal variable is a qualitative assessment of the intensity of collecting seed from on site.

|  |  |  |
| --- | --- | --- |
| **Value** | **Definition** | **Cases** |
| 1 | Seed collecting is minimal; it is something they are struggling to make a regular activity. | C2 |
| 2 | Occasional seed collection happens, no specific program | M4, R2 |
| 3 | Seed collection happens but not an intensive, regular activity | M1, M3 |
| 4 | Active seed collection by staff and volunteers | M2, R1 |
| 5 | Seed collection conducted regularly and intensively and is part of their identity as volunteer restorationists. | C1, C3, C4 |

**22.[seedpurch] Seed purchase:** This categorical variable describes whether organizations have purchased seed or not.

|  |  |  |
| --- | --- | --- |
| Value | Definition | Case |
| 1 | No | C1, C3, C4, R2 |
| 2 | Yes, but avoid when possible | R1 |
| 3 | Yes | C2, M1, M2, M3, M4 |

**23. [seeddist] Seed source distance:** This continuous variable describes the acceptable seed source distance, in miles. See Supplemental Table 6 for the seed distance for each case.

**24. [haowned] Hectares owned by organization:** This continuous variable describes the total number of acres owned by the organization (see Supplemental Table 6). The land size impacts how far the group has to spread their efforts.

**25. [sitesize] Site size:** This continuous variable describes the size of the restored site. (see Supplemental Table 6).

**26. [progress] Perceived restoration progress:** This categorical variable is a qualitative assessment of extent to which people doing the restoration at the site perceive that progress has been made on the site (from perception of change, and quality).

|  |  |  |
| --- | --- | --- |
| **Value** | **Definition** | **Cases** |
| 1 | Low quality, little progress | C2 |
| 2 | Not in great shape, but making progress | M3 |
| 3 | Progress acknowledged but issues of oak regeneration persist | C4, M4, R2 |
| 4 | Significant progress acknowledged on the portion of the site that has been managed; sections of the site have less progress.  | C3, M2, R1 |
| 5 | Near maintenance mode  | C1, M1 |

**27. [impact] Use impact:** This ranked ordinal variable is a qualitative assessment of the degree to which impacts of recreational and other use is a concern.

|  |  |  |
| --- | --- | --- |
| **Value** | **Definition** | **Cases** |
| 1 | No mention of negative use impact; they welcome exposure and use | C2, C3 |
| 2 | A few use issues, but no tension surrounding it. | R2, C1 |
| 3 | Moderately concerned about impacts | C4, M2, M3, M4 |
| 4 | Highly concerned about impacts. | R1, M1  |

## Matrix analysis

The variables used in the full-matrices and submatrices are listed below. Analysis of the overall, positive, and negative emotion showed high correlation between them so we used only overall emotion in the *Full* matrix, and only negative emotion in the *Conflict* submatrix.

**Full matrix:**  time, groupsize, board, publland, regmtgs, dmstyle, difview, volauton, research, public, membership, overemo, numbrule, numbnorm, numbstrat, numbaggr, numbcol, numoper, seedcoll, seedpurch, seeddist, haowned, sitesize, progress, impact

**Organizational complexity:** groupsize, board, mtgstyle, dmstyle, difviews, volauton, membership.[[1]](#footnote-2)

**Attitudes toward restoration:** volauton, research, public, overemo, progress, impact

**Conflict:** dmstyle, difviews, negemo, numbaggr

**Organizational mission:** publland, research, public, membership, impact

**IAD variables:** numbrule, numbnorm, numbstrat, numbaggr, numbcol, numoper

**Seeds:** seedcoll, seedpurch, seeddist

**Site description:** time, publland, sitesize, progress, impact

**Covariates:** time, haowned, sitesize

## Supplemental Table 6. Values for each social science variable used in the integrated analysis.



# Vegetation Data

## Correcting for Sampling Effort

Increased sampling effort (i.e. more plots sampled on a site) adds less-common species to the sample (Legendre and Legendre 2012). Therefore, if two sites have the same relative abundances of the same species, the more intensively sampled site will appear to have more species, and a different species composition, than the less intensively sampled site. Hence, including rarely encountered species would have introduced a bias in our statistical analysis because these species could have appeared more frequently in data sets from larger sites simply because these sites had been sampled more intensively (Figure 4 in the text), and not because of effects of the restoration planning process. Below we describe the rarefaction technique used to correct for sampling effort for woody plants and herbaceous species. The procedures were similar, but differed slightly because actual densities (number of stems per sub-sample) were determined for woody species, but a measure of percent cover was used for the herbaceous species (percent cover was also calculated for woody vines (Figure 4 in the text)).

Abundances of woody-plant species (< 1.5-m tall) were first converted to frequency of observations based on the minimum number of subplots (Figure 4) established within any of the 14 sites. Thus, because the minimum possible observed frequency of a woody species across the 14 sites was 10% (i.e. presence in 1 out of 10 subplots; 5 subplots/plot, two 0.1-ha plots), any species with an observed frequency within a plot < 10% was excluded from the data set from that site. Frequencies of woody species were then converted back to abundances which were summed for each site and then divided by the number of plots in the site.

A similar approach was used to correct for sampling effort for the presence-absence observations of herbaceous species, for which the minimum possible observed frequency across the 14 sites was 4% (i.e. presence in 1 out of 24 subplots; 12 subplots/plot, two 0.1-ha plots). The final list of the herbaceous-species frequency counts was divided by the number of subplots within a site (24-168) and multiplied by 100 to create the percent frequency observed within a site.

## Distance Measures Used in the Multivariate Analyses

Detailed descriptions of the distance measures and the data transformations associated with each measure appear in Legendre and Legendre (2102). Analyses were performed using the chord distance metric (D3) for the herbaceous species data; the distance matrix derived from the Bray-Curtis (or Steinhaus) similarity metric (S17) for woody plant species; and for the invasive-species data set, the distance matrix derived from Gower’s similarity metric (S15) since the data included abundance and frequency variables. Gower’s distance measure also was used for the social data set, since it included a mixture of variable types. Data do not need to be transformed before using the chord or Gower’s distance metric. We square-root transformed the woody plant density data because this is done routinely to de-emphasize the contribution of very abundant species when employing the Bray-Curtis similarity measure.

1. The variables included in “Organizational Complexity” originally included variables describing the rules, strategies, and norms (as reported in Removed for blind review). These were later removed from this variable and instead constituted their own independent variable in the analysis. This strengthened the overall data analysis. [↑](#footnote-ref-2)