Ecological Indicators 77 (2017) 96–104

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Evaluating outcomes in planning: Indicators and reference values for Swiss landscapes

A.M. Hersperger*, G. Mueller, M. Knöpfel, F. Kienast

Swiss Federal Research Institute WSL, Landscape Dynamics, Zürcherstrasse 111, 8903 Birmensdorf, Switzerland

A R T I C L E I N F O

Article history:
Received 18 April 2016
Received in revised form 2 February 2017
Accepted 6 February 2017

Keywords:
Spatial planning
Comprehensive plan
Benchmarking
Ratified values approach
Reference value
Proxy
Landscape quality
Landscape quality goals

A B S T R A C T

Evaluation of achievement of set targets is a necessary step in landscape planning in order to learn from the past, reassess implemented measures and enhance trust in public managers and institutions. Though it is commonly accepted that indicators play a major role in such evaluations, so far no accepted framework for evaluating planning outcomes exists. Furthermore, the selection of appropriate indicators and reference values to effectively assess conditions of landscapes and determine whether observed developments can be considered positive or negative remains challenging. Our study contributes to much-needed research on this topic with a proposed evaluation framework built on goals, indicators and reference values. We analyzed the landscape section of eight Swiss cantonal comprehensive plans to specifically address (1) whether currently tracked indicators suffice to evaluate landscape-planning goals; (2) what a minimal set of landscape indicators for regional planning might look like; and (3) how the ratified value approach could be operationalized to develop reference values for landscape indicators. All eight plans have a similar hierarchical goal system with six major landscape goals, up to 18 themes and 21–33 subordinate goals. The studied cantons track from 29 to 84 indicators. We found a considerable imbalance in the ratio between subordinate goals and indicators, with comparatively few indicators being tracked to assess visual and recreational landscape quality. Our proposed minimal indicator set is well balanced since it lists 5–7 indicators for each theme. The general procedure for modeling reference values is based on the assumption that the protection status of a landscape is a proxy for high societal appreciation of a place. Consequently, indicator values for these areas would reflect reference values (ratified values). We illustrate the procedure with the exemplary indicator *impervious surface*. The proposed indicators and maps are powerful tools for outcome evaluation and also facilitate benchmarking, i.e. interregional comparisons of landscape qualities, which could be very useful for landscape planning in Europe.

1. Introduction

Landscape planning is a part of public policy geared at managing our environment. In the classical planning approach, monitoring and evaluation steps are an integral part of the planning process and draw attention to how closely development decisions conform to planning goals and policies and help assess whether goals stated in the plan have been achieved (Alexander, 1992; Laurian et al., 2010; Steiner, 2008). Methods for evaluation were extensively discussed in the late 1960's and 1970's (Seasons, 2003) when researchers advocated highly structured, quantitative analysis of goals achievement supported by elaborate computer modeling exercises. However, these demanding models were rarely attainable in practice and therefore disappeared. Since then, progress has been slow and even today there is little scientific literature on theory and no accepted methodology for post-implementation evaluation (Brody and Highfield, 2005; Hersperger et al., 2015; Laurian et al., 2010). Furthermore, most evaluation studies evaluate planning outputs (i.e. policies and programs) rather than outcomes (i.e. changes in the real world) (Guyadeen and Seasons, 2016; Oliveira and Pinho, 2010). However, evaluating planning outcomes is necessary for practitioners to learn from the past, and such evaluations contribute to the accountability of, and trust in, public managers and institutions (Seasons, 2003; Wende et al., 2012; Wong, 2011).

Planning outcomes are defined as the effects on socio-economic and environmental systems, including changes in the built environment, caused by the planning system combined with other drivers (Wong and Watkins, 2009). An isolated assessment of the effects of specific planning measures remains challenging because

* Corresponding author.
E-mail address: anna.hersperger@wsl.ch (A.M. Hersperger).

http://dx.doi.org/10.1016/j.ecolind.2017.02.004

it is difficult to draw clear causal links between planning measures and outcomes, and because accepted methodologies are lacking (Carmona and Sieh, 2008; Guyadeen and Seasons, 2016). Still, recent research has evaluated the outcomes of urban growth boundaries intended to preserve open landscapes (Gennaio et al., 2009) or greenways designed to contain urban growth (Siedentop et al., 2016).

It is commonly accepted that indicators play a major role in planning evaluations (Mönnecke, 2008; Wong, 2011, and this is also true for landscape-planning evaluations (Mueller and Hersperger, 2015). However, landscape planning is a highly complex cross-policy procedure integrating ecological, recreational and aesthetic aspects on regional scales and the selection of appropriate indicators and reference values is challenging. Our study contributes to the much needed research by proposing in section two a concept for indicator-based outcome evaluation that is tested and illustrated with empirical data from the landscape section of the Swiss cantonal comprehensive plans. Section three presents the test methods; section four shows the results; section five discusses test results and concept; and section six provides concluding remarks.

2. Building blocks for evaluation

Building on Fürst and Scholles (2008), we identified building blocks that need to be addressed in an evaluation of landscape-planning outcomes, i.e. goals, indicators and reference values (Fig. 1). To successfully integrate evaluation into landscape planning, the development of these building blocks should be closely interlinked.

2.1. Goals

Landscape-planning goals depict desired improvements or envisioned states and are normally rather broad. Consequently, it is often impossible to directly evaluate the degree to which they are achieved. Instead, indicators are selected by landscape planners to measure particular aspects of the goal (Fürst and Scholles, 2008; Keiner, 2003).

2.2. Indicators

A major challenge of landscape-planning evaluation is to select relevant indicators that depict the outcomes of landscape planning. In particular, the indicators have to fulfill the following criteria:

(1) show a clear link between indicators and goals;
(2) are easily measurable and sensitive to external change (Müller and Lenz, 2006);
(3) are able to capture complex concepts such as landscape aesthetics, landscape quality and landscape diversity (Kienast et al., 2015);
(4) are representative for a specific geographic region (Bottero, 2011; Niemeijer and de Groot, 2008).

Unfortunately, constraints in time, money and personal resources often lead to low sampling intensity, and therefore low informative value, and long data series are seldom produced (Knöpfel et al., 2011). In order to save resources, a minimal-set of indicators is commonly designed with the lowest number of indicators necessary to address all goals. Ideally, planning evaluation relies on established indicator sets and monitoring programs (Kienast et al., 2015). For Switzerland, a comprehensive monitoring program, the Swiss Landscape Observatory (LABES), is available (Kienast et al., 2013; Roth et al., 2010). LABES follows the DPSRI paradigm and consists of 30–35 indicators including ecological indicators, land-use parameters, aesthetic and recreation-oriented indicators, as well as a fully representative survey of people's attitudes towards their nearby landscape. Other studies proposing broad arrays of landscape indicators are presented in Cassatella (2011) and Uuemaa et al. (2013).

2.3. Reference values

Reference values are needed to define target values to effectively assess conditions of landscapes and to determine whether observed developments can be considered positive or negative (Berke and Godschalk, 2009). In practice, qualitative targets can easily be derived from planning goals based on the desired trends for the development (e.g. no further increase of settlement area, increase of ecological compensation areas) (Fürst and Scholles, 2008). Quantitative target values are, however, mostly lacking because: (1) explicit quantified targets for indicators have little political support since flexible planning strategies are preferred (Knöpfel et al., 2011; Artmann, 2014); and (2) there is a lack of theory and data for defining quantified references. This issue has been discussed in detail in the context of indicators of cultural ecosystem services for urban planning (e.g. La Rosa et al., 2016).

A promising concept for deriving such reference values is the ratified values approach, as suggested by Cassatella (2011). The ratified values approach is based on the "acknowledgement of the value attributed by institutions acting in the name of the community and public interest, for instance with administrative acts such as designations or restrictions" (Cassatella, 2011; p.110). The protection of a landscape is usually based on a common understanding of a place's unique value. In this sense, protected landscapes can be considered a proxy for perceived landscape quality (Cassatella, 2011; Peano et al., 2011). The ratified values approach is a normative concept since the establishment of conservation areas is based on value judgements. To our knowledge, so far the ratified value approach has not been operationalized and applied.

In order to illustrate the main challenges of applying the outlined building blocks of evaluation, we analyzed the landscape section of the Swiss cantonal comprehensive plans and specifically addressed the following questions:

1. Are currently tracked indicators sufficient to evaluate landscape-planning goals?
2. What does a potential minimal set of indicators look like at the regional scale?[1]
3. How can reference values be developed with the ratified value approach?

Landscape sections of Swiss cantonal comprehensive plans provide valuable examples for illustrating the building blocks in a strongly participatory, federalist planning environment. Thus, the primary target audience of our paper is land managers and planners of societies where planning has a strong bottom-up approach. Cantonal comprehensive plans represent the centerpiece of spatial planning in Switzerland. They have a broad scope and cover topics such as transportation, settlement development, energy supply, and landscape conservation (Muggli, 2012). Comprehensive plans usually consist of a strategic section, which includes the general guidelines for future spatial development (e.g. stopping a trend of urban sprawl) and subordinate long-term planning goals (e.g. densification of settlements). The strategy is complemented by thematically organized task-sheets that describe concrete planning tasks and a map that facilitates coordination.

[1] For a comprehensive discussion of the landscape concept and the relevance of the regional scale for planning see Termorshuizen and Opdam, 2009.

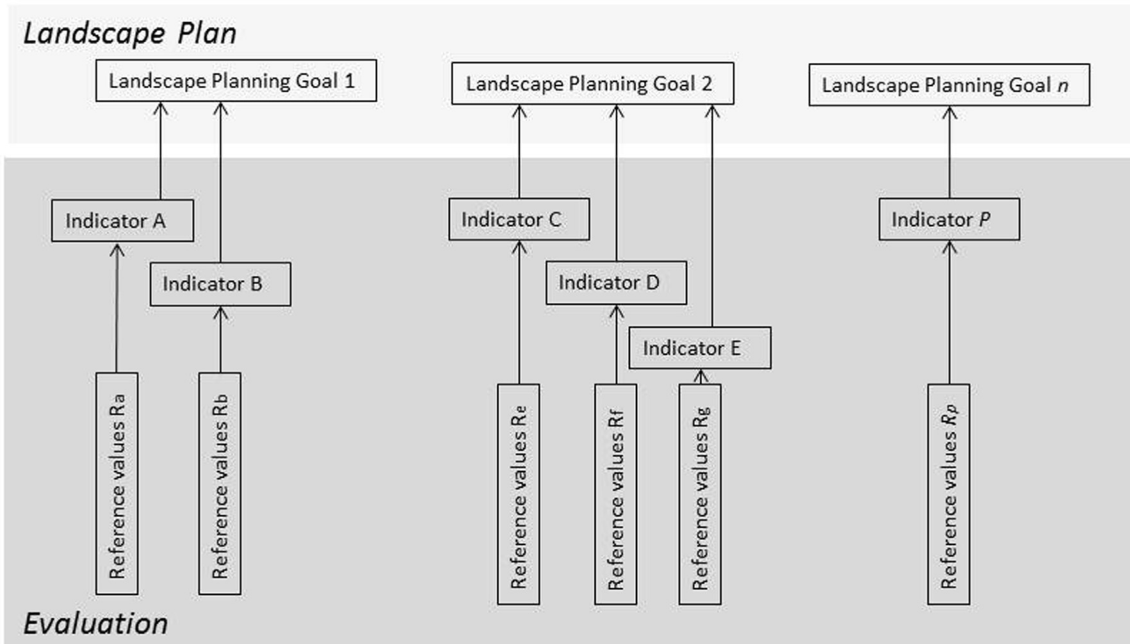

Fig. 1. Building blocks of evaluation in landscape planning: goals, indicators and reference values.

3. Methods

3.1. Identifying landscape goals in cantonal comprehensive plans

Landscape goals were derived from the text section of the cantonal comprehensive plans of eight Swiss cantons (Aargau, Berne, Glarus, Lucerne, St. Gallen, Vaud, Zug and Zurich), status of December 2010. The eight cantons cover 16,700 km^2 and house a population of 4.7 Mio. They were chosen because they represent a diversity of landscapes and include German and French speaking regions. For the canton Aargau, the draft of the general revision was analyzed; for the canton Lucerne, the version was not yet approved by the federal council at the time of the analysis. The entire comprehensive plans were screened since landscape related goals can be found in many plan sections due to the interdisciplinary nature of landscape planning. Since all plans contained three levels of goals one general goal system with major goals, themes, and subordinate goals was designed. Major goals refer to broadly formulated intentions of improvement in commonly accepted subfields of landscape planning (e.g. habitats, resources, and recreation). Themes characterize main aspects within the major goals (e.g. "soil"," air", "water" within the major goal "safeguard and enhance natural resources") whereas subordinate goals refer to very specific goals found in the plans. Items with the same meaning were merged and goals without a strong landscape reference (e.g. goals on drinking-water quality) were omitted. As a result, a hierarchical system with six major landscape goals, 18 themes, and 68 subordinate goals was derived.

3.2. Identifying currently tracked indicators

Many cantons monitor landscape indicators not only in landscape monitoring programs but in context with diverse monitoring and controlling activities. Therefore, we searched cantonal documents on the internet, i.e. reports on spatial planning, sustainability performance, spatial monitoring, controlling, and financial planning and assembled for each canton all indicators it tracks, without applying any filters. We verified the list in interviews with cantonal administrators: we interviewed three administrators from canton Aargau; two from Bern, Luzern, St. Gallen and Vaud; and one from Glarus and from Zurich. Most of the interviewees represented cantonal planning agencies but some also stood for government agencies on sustainable development, nature and landscape protection, and rural development. The goal was to interview the government officials who know most about landscape indicators within their canton. The interviews were recorded, transcribed and subsequently analyzed using qualitative content analysis.

3.3. Matching indicators and landscape goals

For each canton, we linked each indicator with the appropriate theme and determined through aggregation the number of indicators that measure each theme and major goal. In order to assess if there were sufficient indicators to measure a major goal, the number of subordinate goals (in percent) was compared with the number of indicators (in percent). We stipulated that, for a meaningful evaluation, the ratio between subordinate goals and indicators should be similar for all goals. Instead of measuring complex goals with many indicators and simple goals with few indicators, the former should be subdivided so that, within a given goal-system, all goals are similar in complexity and can be tracked with a comparable number of indicators. Spider diagrams were developed to illustrate the ratios in order to evaluate how balanced the indicators and subordinate goals were per goal and canton. In order to account for the large differences in number of goals and indicators among cantons, the spider diagrams show percent values.

3.4. Developing a minimal indicator set

There is a large amount of literature on indicator selection, see e.g. (Hasund, 2011). Here, we do not repeat the excellent overviews of indicator selection criteria provided previously (Hasund, 2011; Niemeijer and de Groot, 2008; Ode et al., 2008). To generate an indicator set with least correlated indicators we relied on findings of Kienast et al. (2015) who showed that landscape indicator sets should not consist of more than 2–5 indicators per theme, as higher numbers bear a high risk of redundant information. For indica-

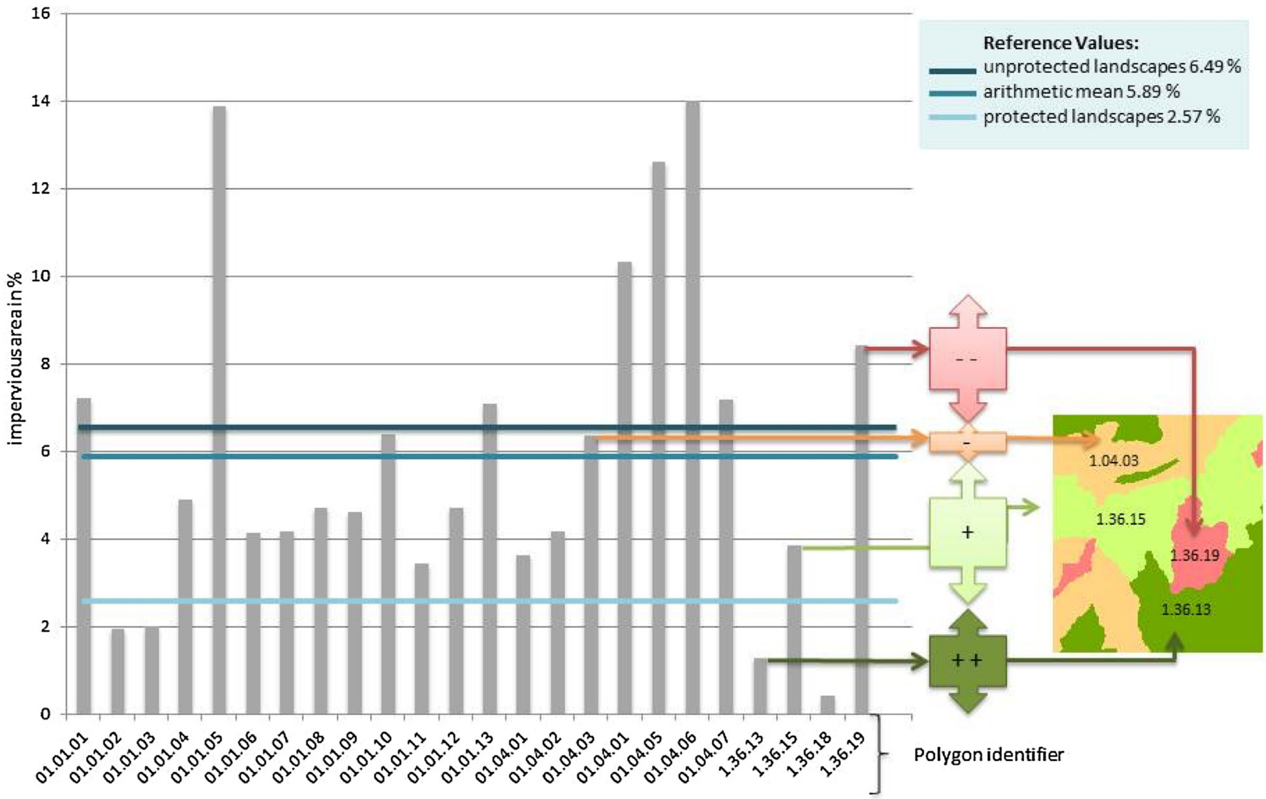

Fig. 2. Method used to develop reference values for indicators and to assign polygons to categories, shown for the indicator impervious surface and the landscape type Jura mountain (valleys).

tor selection we used indicators from Swiss landscape monitoring LABES since they are readily available, checked for redundancy, and nationally tracked.

3.5. Modeling reference values for landscape indicators

When defining reference or target values for landscape indicators used for evaluations, it makes sense to take into account regional differences in natural and socio-economic conditions since not all regions have the same ability to achieve certain outcomes and corresponding indicator values. For this study, we distinguished among 13 landscape types that are representative of the great diversity of landscapes in Switzerland, ranging from pristine mountain areas to densely populated urban areas. The landscape types are derived from the Swiss Landscape Typology, which is based on numerous physio-geographical and land-use factors (ARE, 2011a,b). The initial 39 types were aggregated into 12 landscape types, taking into account the three biogeographical regions (Alps, Central plateau, Jura mountains) as primary units and topography (valleys, plains, hilly areas, mountainous areas, high mountains) as subordinate units. The unit Jura mountains (high mountains) was combined with the unit Jura mountains (hilly areas) since it consists of a single polygon. Urban areas formed a separate unit. The 12 landscape types covered between 100 km^2 (Alps (hilly areas)) and 11,700 km^2 (Alps (mountainous areas)) and contained between six and 85 polygons (Jura mountains (mountainous areas) and Alps (high mountains), respectively).

We developed a general procedure for modeling reference values based on the ratified values approach and tested it with the indicators *Area without buildings and infrastructure*, *Area with few buildings and infrastructure*, *Change in agricultural areas*, *Buildings in areas not zoned for urban development*, *Urban sprawl*, and *Impervious surface*[2] (Müller et al., 2015). In this paper, the method is illustrated with the indicator *Imperious surface* (surface of paved areas, buildings and green houses as a percent of the total area) and the landscape types Jura Mountains (valleys), Central plateau (plains), Central plateau (hilly areas), and Alps (high mountains). This indicator was chosen for the illustration because the amount of impervious surface is a key factor in most landscape-planning endeavors and because the indicator can be derived from readily available remote-sensing data.

We defined three spatial entities for deriving the reference values: 1) *Protected landscapes* were the highest reference level and consisted of all areas strictly protected for their aesthetic or ecological value by the Federation or the Cantons. Landscapes with limited protection status allowing some development (i.e. regional parks) were not included in this highest reference level. 2) *Unprotected landscapes* were the lowest reference-level. These two normative references were complemented by 3) the *arithmetic mean* of Switzerland as an intermediate, statistically defined reference-level. Thus, for each indicator and landscape type, three landscape-type-specific reference-levels could be calculated. For example, the highest reference level for impervious surface equaled the impervious surface (in percent) of all protected landscapes within a landscape type.

In order to evaluate the performance of polygons or regions, the value of the indicator impervious surface was calculated for each polygon within a landscape type (in the example: for the valleys in the Jura Mountains). Next, these values were compared with the three landscape-type-specific reference-levels (see Fig. 2). In doing so, each polygon could be assigned to one of four categories: a poly-

[2] Impervious surface has been estimated by using the official Swiss land-use statistics by extracting buildings, paved surfaces and greenhouses.

Table 1
Landscape goals, themes, number of subordinate goals and number of tracked indicators, based on the assessment of eight cantons.

Major goals		Themes	Number of subordinate goals per canton (range)	Number of indicators per canton (range)
A	Preserve habitats for protection of fauna and flora	- Valuable landscapes and regions - Fragmentation - Nature-oriented forest ecosystems - Nature-oriented water bodies - Nature-oriented agriculture	6–12	6–32
B	Safeguard and enhance natural resources	- Soil protection - Air pollution prevention - Water pollution prevention	2–8	10–30
C	Create opportunities for recreation	- Areas for recreation - Access to recreation areas - Residential quality (Wohnqualität)	0–5	0–3
D	Maintain/facilitate economic competitiveness	- Agriculture - Forestry - Tourism	1–3	0–6
E	Enhance and preserve the landscape's visual quality	- Overall appearance of the landscape - Appearance of the settlements - Spatial distribution of settlements	0–7	2–14
F	Protect humans	- Protection from natural hazards, noise and radiation	1–4	0–8

gon was assigned the category (++) if the impervious surface in this polygon was lower than the highest reference value, i.e. the value in the protected landscapes of this landscape type. If the proportion of impervious surface was between the highest reference value and the arithmetic mean, the polygon was assigned the category (+). If the proportion of impervious surface was between the arithmetic mean and the lowest reference value, i.e. the unprotected landscapes, it was assigned the category (−). Finally, if the proportion of impervious surface exceeded the lowest reference value, the polygon was assigned the category (–). The categories were then mapped to show the performance of the polygons regarding the respective indicator. The analysis was executed with ArcGIS.

4. Results

4.1. Balance between goals and tracked indicators

Table 1 depicts the hierarchical goal system derived from the eight plans. Most goals were qualitative; very rarely did we find quantitative values or thresholds. Each comprehensive plan covered all six major goals and most of the themes and listed between 21 and 33 subordinate goals. In all cantons, most subordinate goals were associated with the goals "Preserve habitats for protection of fauna and flora", and only few were associated with "Protect humans", "Maintain/facilitate economic competitiveness" and "Create opportunities for recreation" (Fig. 3). There were large differences among cantons in the number of subordinate goals per goal, in particular in the categories "Preserve habitats for protection of fauna and flora" and "Enhance and preserve the landscape's visual quality". Almost no variation was found in the goals "Maintain/facilitate economic competitiveness" and "Protect humans".

The number of tracked indicators ranges from 29 (Lucerne) to 84 (Aargau). Cantons tracked up to 32 indicators for a major goal (Table 1). For "Create opportunities for recreation", "Maintain/facilitate economic competitiveness", and "Protect humans", all cantons hardly tracked any indicators. Overall, few indicators were explicitly tracked for evaluating landscape-related goals, whereas many landscape indicators were used in other government activities. Only few indicators corresponded with the indicators of LABES. According to the analysis, Canton Glarus currently tracks only one indicator and is pursuing the development of a joint monitoring and controlling project in cooperation with the canton of St. Gallen.

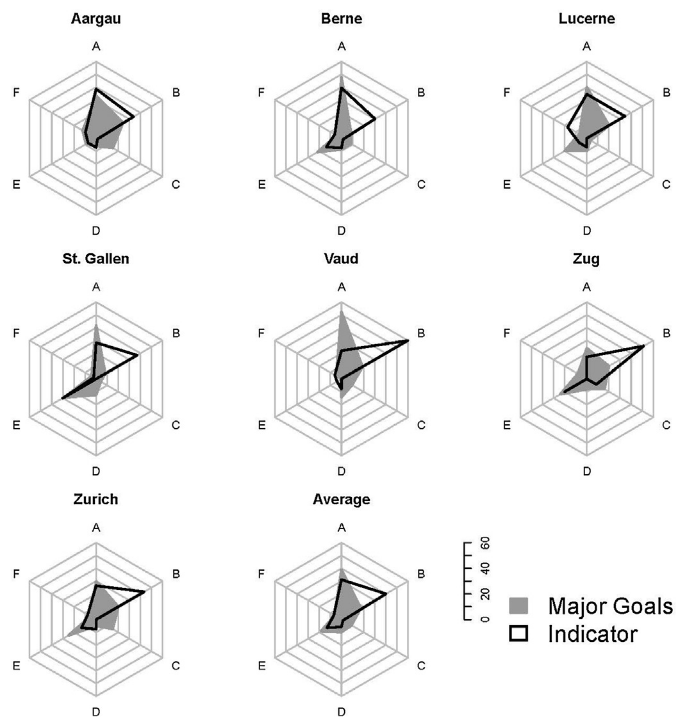

Fig. 3. Spider diagrams showing the subordinate goals and indicators (in percent) for the six main goals for seven cantons and the average of all cantons. Canton Glarus is omitted because this canton only tracked a single indicator. A: Preserve habitats for protection of fauna and flora; B: Safeguard and enhance natural resources; C: Create opportunities for recreation; D: Maintain/facilitate economic competitiveness; E: Enhance and preserve the landscape's visual quality; F: Protect humans.

Averaged over all cantons, we found a considerable imbalance between the number of subordinate goals and the number of indicators used to measure these goals (in percent) (Fig. 3). This was particularly true for the major goal "Safeguard and enhance natural resources", which had many more indicators than goals. In contrast, for "Preserve habitats for protection of fauna and flora ', "Create opportunities for recreation', 'Maintain/facilitate economic competitiveness', and "Enhance and preserve the landscape's visual quality", we find more subordinate goals than indicators. The biggest imbalance between subordinate goals and available indicators was found for "Create opportunities for recreation" and "Safeguard and enhance natural resources". Spider diagrams (Fig. 3) allowed a quick and easy assessment of the imbalance between subordinate goals and indicators for the six goals. Aargau exhibited a rather good balance, whereas St. Gallen, Vaud and Zug were quite unbalanced.

4.2. Minimal indicator set for evaluating outcomes in landscape planning

The minimal set of indicators is shown in Table 2. This set is balanced with respect to themes, as it has 1–4 indicators per theme and 4–7 indicators per goal. In order to link our minimum set with international work, Table 2 lists equivalents from the European Union indicator sets and from a regional landscape monitoring program from Northern Italy (Peano et al., 2011). The latter was used since it represents an excellent and comprehensive example of a regional landscape monitoring.

4.3. Reference values for indicator impervious surface

The ratified values approach delivered the expected pattern, i.e. unprotected landscapes showed the highest percentage of impervious surface and protected landscapes the lowest (Table 3). For all three spatial entities, the lowest values of impervious surface were found in the high Alps, and the highest values were found in urban areas. The reference values in the plains of the Central plateau were 10.1% for unprotected landscapes, 9.0% for the arithmetic mean, and 5.0% for protected landscapes. These values are considerably higher than the corresponding values in others landscape types, e.g. the valleys of the Jura mountains (6.5% unprotected areas, 5.9% arithmetic mean, 2.6% protected landscapes). This finding is in line with broad patterns of land-use intensity.

The reference values can now be used to define targets and evaluate outcomes. A canton can, for example, state: The impervious surface in all landscape types should be lower than the value in the column "arithmetic mean" in Table 3. For a more ambitious goal, the canton could request that the impervious surface value should be lower that the values listed in the column "protected landscapes". A canton could also chose to set strict targets for selected landscape types (e.g. Alps, mountainous areas) and milder targets for others (e.g. Urban areas) in order to reflect a differentiated development strategy. Thus the reference values serve as useful guides for defining quantified targets in a political process. In order to perform an evaluation the impervious surface needs be measured in two to four years again to see if the target is achieved or if there is progress towards the target. In the context of current comprehensive plans, that do not specify quantified targets as of now, the reference values can be used for benchmarking, i.e. comparisons across regions. This is shown in the next section.

4.4. Evaluation of current landscape regarding impervious surface

In order to evaluate the current landscape, each polygon was assigned to a category indicating relative quality (++,+–, –), as specified in the methods section. Fig. 4 illustrates the results for the landscape types Jura mountains (valleys), Central plateau (plains), Central plateau (hilly areas), and Alps (high mountains). The maps visualize the assessment of all polygons in a landscape type and are especially useful for regional comparisons. Areas with category (–) seem to be mainly concentrated around the most densely populated central area of the plateau, e.g. the greater Zurich metropolitan area in the northeast and the Lake Geneva region in the southwest with the booming cities of Lausanne and Geneva (maps Central plateau (plains) and Central plateau (hilly areas) in Fig. 4). The map for the Alps (high mountains) shows that the areas towards the northern edge of the mountain range have more impervious surface than the rest of the high mountain areas, which have a larger proportion of protected landscapes. Furthermore, areas with touristic infrastructures, such as the ski resorts St. Moritz and Zermatt, have high levels of impervious surface (category –).

5. Discussion

In this paper, we argue that the evaluation of outcomes in landscape planning should be conceptualized as an overarching endeavor, linking goals, indicators and reference values. By doing so, early steps of the planning process, i.e. the identification of visions and goals, can be linked with later stages, i.e. monitoring and evaluation.

5.1. Goals and indicators

Our research showed an imbalance regarding the ratio between subordinate goals and indicators in all Cantons and for several goals. We believe that a good indicator set should be balanced, i.e. each goal should be measured with a similar number of indicators since an asymmetry can lead to a hidden allocation of weights. Imbalances often stem from a lack of resources and from difficulties in operationalizing vague goals (Hersperger et al., 2011). The minimal indicator set proposed in Table 2 provides an ideal match, in that each of the goals, consisting of 3–5 themes, is measured with 5–7 indicators. A European monitoring program that tracks a minimal set of landscape indicators could be of great benefit in order to perform evaluations from regional to international scales within Europe. Whereas it is not necessary to track exactly the same indicators for all areas, it needs to be clear how indicators relate to each other.

Despite wide agreement that goal systems should be adapted to regional specificities (Fürst and Scholles, 2008; Meadows, 1998; Perdicoulis and Glasson, 2011), the eight Cantons had rather similar goals that were generalized into the goal system of Table 1. This system corresponds to a large extent with landscape sustainability goals as expressed at international, national and regional levels throughout Europe. Also, it could be easily linked with the classification of ecosystem services (Potschin et al., 2016) and moreover with ecosystem service indicators as shown by Müller et al. (2016). This flexible docking to existing evaluation schemes is an advantage when transferring our results to other regions or countries.

5.2. Strengths and limitations of the applied ratified value approach

To our knowledge this is the first time, in Switzerland and internationally, that ratified values have been developed as suggested by Cassatella (2011). However, administrators were very interested when we presented the study in a workshop at the Federal Office of Spatial Development.

A strength of the applied ratified value approach is its normative character (Cassatella, 2011). Using the protected areas as a proxy allows one to take into account what people are willing to protect. Therefore, the approach could be very suitable for European assessments that need to address Europe's high diversity of cultural landscapes and regional values. The use of landscape protection as a proxy for landscape value can, however, be problematic if a landscape has been protected in the past because of its special quality but has not been managed to keep this quality. In such cases another approach is needed to define target values. Also, it would be interesting to explore in future studies the consequences of considering multiple designations, i.e. giving the areas with multiple designations more weight when calculating the reference values.

The reference values, illustrated with the example of impervious surfaces, provide three lubber's points to stakeholders, planners

Table 2
Minimal indicator set based on indicators of the Swiss landscape observatory LABES.

Goals Themes	LABES Indicator	Indicators or data sets used as proxies from regional level sets (italic) and European level sets
Preserve habitats for protection of fauna and flora		
Valuable landscapes and regions	• Federal landscape and nature conservation areas	Designated areas (CSI 08)[a]
	• Public funds for landscape and nature protection	Species diversity (CSI 09)[a]
Fragmentation	• Landscape fragmentation	Landscape dissection (LUCAS)[c] Fragmentation of natural and semi-natural areas (SEBI 13)[a]
Nature-oriented forest ecosystems	• Areas of low-intensity forest use	Abundance and distribution of selected species (SEBI 001)[a] Designated areas (CSI 08)[a]
Nature-oriented water bodies	• Ecomorphology of rivers	(None available according to our knowledge)
Nature-oriented agriculture	• Percentage area with agri-ecological measures	Area under organic farming (CSI 26)[a]
	• Diversity of agricultural use	Agriculture: area under management practices potentially supporting biodiversity (SEBI 020)[a]
Safeguard and enhance natural resources		
Soil protection	• Impervious surface	Land take (CSI 14)[a]
	• Soil consumption for infrastructure	
Air pollution prevention	(Air and water pollution indicators are not considered landscape indicators sensu stricto)	Exposure of ecosystems to acidification, eutrophication and ozone (CSI 5)[a]
Water pollution prevention		Freshwater quality (SEBI 16)[a]
Create opportunities for recreation		
Areas for recreation	• Accessibility of nearby recreation areas	Recreational benefits (Peano et al. 2011)
	• Percentage of water edges freely accessible	
Services for recreation areas	• Trails for pedestrians and hikers	Recreational benefits (Peano et al. 2011)
Residential quality (Wohnqualität)	• Distance to central services	Accessibility to basic services and markets by transport mode (TERM 15)[a]
	• Residential quality and well-being (objective)	(None available for residential quality/appearance of settlements according to our knowledge)
Maintain/facilitate economic competitiveness		
Agriculture	• Change of agricultural area	CORINE data[d]
Forestry	• Change of forest area	CORINE data[d]
Tourism	• Area with a low density of buildings and infrastructure suitable for tourism	Penetration of tourist eco-labels (YIR01TO12)[a]
	• Authenticity (perception indicator)	Tourism infrastructure in rural area (CMEF 31)[b]
	• Fascination (perception indicator)	
	• Distinctiveness of the landscape (character and reference to the past)	
Enhance and preserve the landscape's visual quality		
Overall appearance of the landscape	• Perceived landscape beauty	Variety, Tranquility, Amenity, Landscape significance, Imageability (Peano et al. 2011)
	• Perceived landscape structure (information content), i.e. complexity, coherence, mystery, legibility (Kaplan & Kaplan)	
Appearance of the settlements	• Perceived residential quality and well-being	
Spatial distribution of settlements	• Urban sprawl	Land take (CSI 014, LSI 001)[a]
	• Land consumption for settlement areas	
	• Built-up area outside zones intended for construction	
Protect humans Protection from natural hazards, noise and radiation	[e]	(None available according to our knowledge)

[a] http://www.eea.europa.eu/data-and-maps/indicators/#c5=&c7=all&c0=10&b_start=0 (January, 29, 2016).
[b] https://ec.europa.eu/agriculture/statistics/rural-development/2011_en (February 7, 2017).
[c] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Landscape_structure_indicators_from_LUCAS (December 10, 2012).
[d] http://www.eea.europa.eu/data-and-maps/data#c17=&c11=&c5=all&c0=5&b_start=0 (January 29, 2016).
[e] Natural hazards, noise and radiation is in Switzerland not addressed in LABES.

Table 3
Reference values for impervious surface (%), derived from unprotected landscapes (weakest reference value), protected landscapes (strictest reference value), and mean value of total area of landscape type.

	Landscape types	Area of Switzerland (%)		Reference values (% impervious surface)		
		Unprotected landscapes	Protected landscapes	Unprotected landscapes	Arithmetic mean	Protected landscapes
1	Jura mountains (valleys)	72.0	12.5	6.5	5.9	2.6
2	Jura mountains (hilly areas)	53.9	22.2	4.2	3,3	2.4
3	Jura mountains (mountainous areas)	37.8	27.3	0.9	0.8	0.7
4	Central plateau (valleys)	66.4	26.0	9.2	6.9	3.7
5	Central plateau (plains)	85.6	12.5	10.1	9.0	5.0
6	Central plateau (hilly areas)	77.6	15.5	5.5	4.7	3.0
7	Central plateau (mountainous areas)	54.6	20.6	2.4	1.9	1.2
8	Alps (valleys)	83.6	13.8	11.8	9.9	5.0
9	Alps (hilly areas)	56.4	42.4	5.4	4.0	1.9
10	Alps (mountainous areas)	58.8	27.7	3.4	2.5	1.4
11	Alps (high mountains)	35.9	47.4	0.2	0.1	0.1
12	Urban areas	92.9	6.5	28.2	27.3	13.6

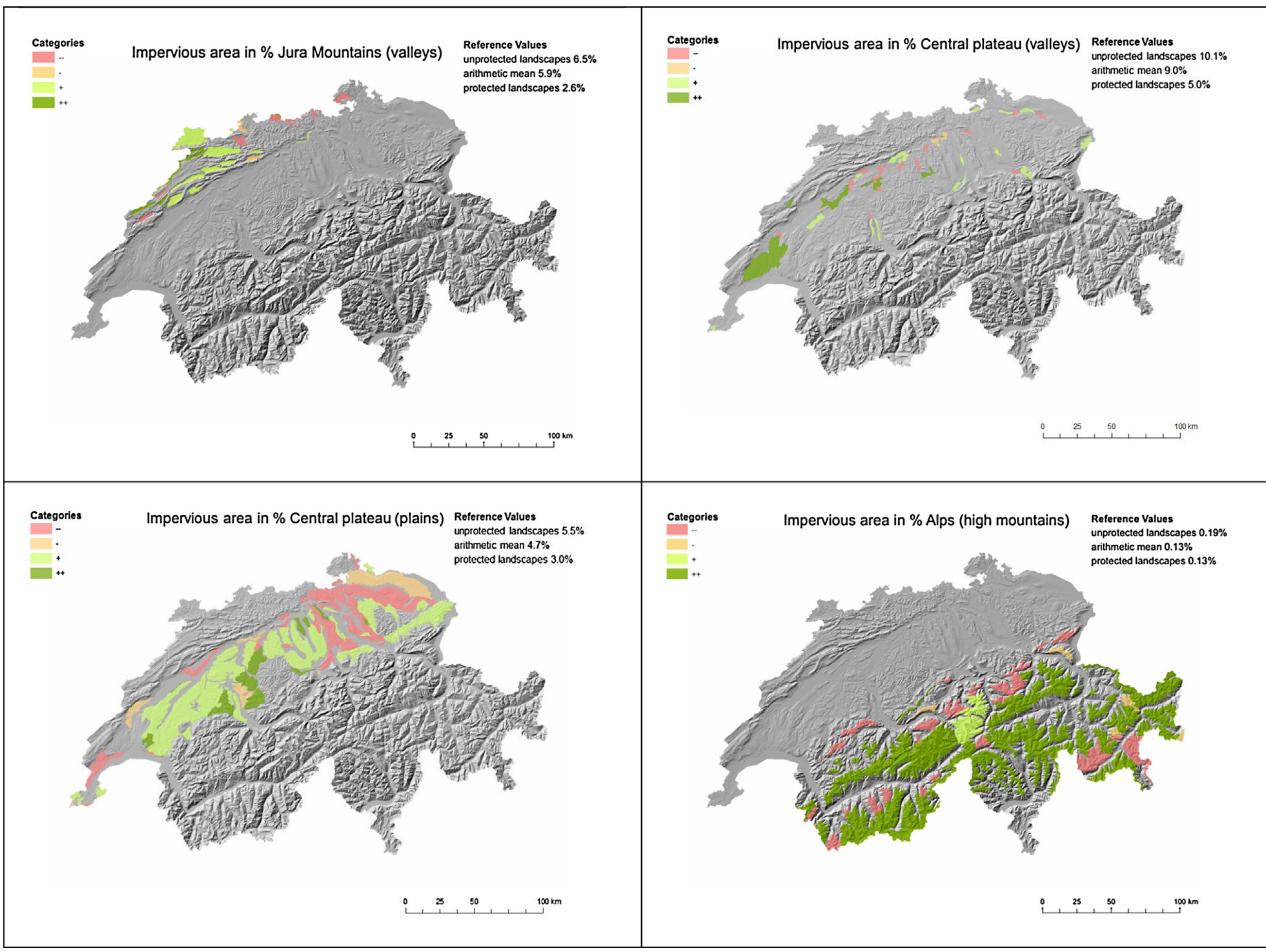

Fig. 4. Assessment of impervious surface in four quality classes in the landscape types Jura mountains (valley), Central plateau (plains), Central plateau (hilly areas), and Alps (high mountains).

and politicians in the discussion to set quantified targets. It is crucial that such targets become standard in landscape planning. Until then, the reference values are extremely valuable for benchmarking. Benchmarking is greatly facilitated by the use of comparable goal systems and indicators, as well as a meaningful landscape typology that permits comparison of landscapes of similar characteristics. Such benchmarking has, for example, been discussed for comprehensive planning in Switzerland (Keiner, 2003) and would be very useful for landscape planning in Europe.

When interpreting the results of outcome evaluations, it has to be considered that planning is one driver among others that affects landscape development (Hersperger and Burgi, 2009, 2010). Furthermore, the effects of planning usually manifest themselves with a considerable time lag. Thus, drawing causal conclusions about the effect of planning based on signals picked up by indicators is challenging. However, maps as shown in Fig. 4 can heuristically indicate areas with a potential or deficit in terms of a specific landscape quality. These findings can inform planning, for instance by suggesting planning measures that showed promising results in another region.

6. Conclusion

We found that currently tracked indicators are overall not sufficient to evaluate landscape-planning goals. However, the 27 indicators presented in the minimal set would enable the cantons, or respective regional governments, to monitor all relevant landscape aspects. The ratified values approach applied to landscape indicators proved suitable to identify three reference values that specify different degrees of quality. These values can support actors in the political process to set quantified targets which are necessary for indicator-based evaluation of planning outcome. The presented concept based on goals, indicators and reference values is flexible enough to allow for regional needs but standardized enough to allow benchmarking and knowledge exchange.

Acknowledgements

This research was funded by the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), the Cantons Aargau, Glarus, Lucerne and St. Gallen through the WSL Program "Room for People and Nature" and the Swiss National Science Foundation (grant number BSCGIO 157789). We would like to thank the interview partners for generously contributing their time and for sharing their expertise, C. Cassatella for comments regarding the ratified values approach, and two reviewers for their helpful comments. Special thanks to M. Dawes for providing English language corrections.

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