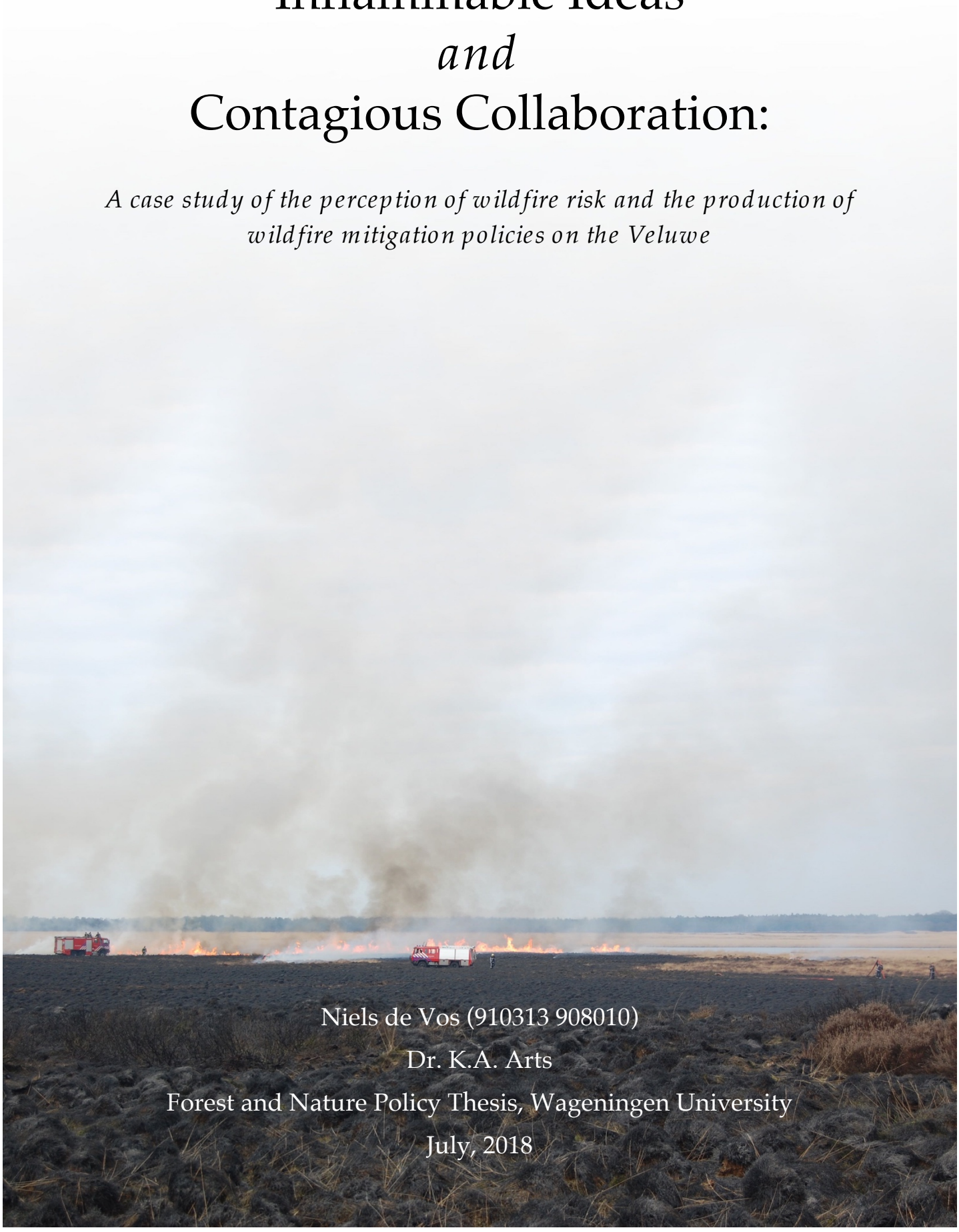
Inflammable Ideas
and
Contagious Collaboration:

A case study of the perception of wildfire risk and the production of wildfire mitigation policies on the Veluwe



Niels de Vos (910313 908010)

Dr. K.A. Arts

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Preface

It's spreading like wildfire. This no longer is only a metaphor, the wildfires are really extending in most parts of the world. Most likely this will not skip the Netherlands. How are we to go about them? In this time of discussion about climate change mitigation and adaptation it is important to consider how we are doing in this regard. Are we doing our best to intervene or to adapt, and what can be done better by whom? Is intervention even necessary? How is the wildfire risk perceived, and how is expertise about it developed and shared between actors affected? These questions were driving the research.

Writing this thesis for me has been a long process in which I have learned many things, not only about the subject, but also in researching skills, and academic thinking. Creating a consistent framework from theories, operationalizing them and reporting on this was quite a challenge, but therefor an instructive one.

I want to thank my supervisor Koen Arts for his ideas, inspiration, drive and patience. He showed me often how to go forward when things were complicated and made me be the best I could, the best he could. I also want to thank all respondents that I interviewed for their time and stories. Besides it being very interesting to meet them in their working (and sometimes natural) environment, they provided the primary data from which this research could draw its conclusions. I hope they can also be of relevance in return to them and to the nature and safety of the Veluwe, and the other beautiful Dutch natural areas.

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Tables and figures

Abstract

Wildfires in the Netherlands are predicted to grow in intensity and number as an effect of global warming. While wildfires used to be the concern of the safety sector, this concern is now increasingly shared by other sectors, including that of nature conservation.

Eight stakeholders of the wildfire problem on the Veluwe were interviewed and their responses analyzed against 21 indicators. The stakeholders represented the safety sector, public and private terrain managers and (local) government. The thesis' objective was to understand how the wildfire problem was perceived by them, how they are collaborating in the policy production at the intersection between nature management and wildfire risk mitigation and what discrepancies emerge from this process.

Even though from a safety perspective, wildfire was generally perceived as a real risk for the Veluwe, from a natural perspective, the benefits for ecosystems were also recognized by some stakeholders. Sectoral differences turned out to be explanatory for the way wildfire risk was perceived. Only the safety sector stakeholders linked wildfires to climate change, the others saw yet no reason to make the connection. Society is too much influenced by hypes of wildfire risk which is inflated by the use of risk color codes and by the media, almost all stakeholders think. Eight measures are implemented in nature management and wildfire fighting to mitigate the wildfire risk. The collaboration needed for these policies was mostly successful, and special expertise of certain stakeholders is well used by the others. However, some barriers are still not overcome: differences in values, routines and prejudices fed by disappointments need communication and exercise to be overcome. Because of these barriers, some measures were not completely implemented, and thus wildfire risk mitigation is still not optimal. Institutional learning capacity can grow the adaptivity of stakeholders for changing circumstances in the future. The safety sector showed the highest learning capacity, with the (local) government coming second, and terrain managers having the lowest score for learning capacity.

Keywords: wildfire, Veluwe, safety sector, terrain managers, policy cycle, risk society, learning capacity

Abbreviations

Abbr.	Meaning	Translation
ASK	Artillerie Schietkamp	Artillery shooting range
CoPI	CommandoPost Incident	Incident Command Point
CRNV	Commissie Risicobeheersing Natuurbranden Veluwe	Committee Wildfire Risk management Veluwe
GGA	Gebiedsgerichte Aanpak	area specific approach
IFV	Instituut Fysieke Veiligheid	Institute for Structural Safety
ISK	Infanterie Schietkamp	Infantry shooting range
MoD	Ministry of Defense	Ministerie van Defensie
RIN	Risico Index Natuurbranden	Wildfire Risk Index
VBC	Veluws Bosbrand Comité	Wildfire Committee Veluwe
VBNE	Vereniging van Bos- en Natuurterreineigenaren	Forest and Nature reserve owners association
VNOG	Veiligheidsregio Noord-Oost Gelderland	Safety region North-east Gelderland
WUI	Wildland-Urban Interface	Raakvlak stad-natuur

CHAPTER 1

Introduction

Global warming, caused by trapping thermal radiation in the earth atmosphere due to increased anthropogenic emissions of greenhouse gases, is already having a variety of effects. The net melting of the arctic regions is leading to a sea level rise which threatens low-lying countries such as the Netherlands. In western Europe the biggest impacts are expected on marine ecosystems, river discharge and wildfires (IPCC, 2014).

Warmer air can contain more water, so there is more evaporation. Rising temperatures lead thus to drier vegetation and soil and more droughts (Jones, 2017). This increased heat and water stress has already caused mortality of oak, fir, spruce, beech and pine species in France, but also of *Pinus sylvestris* in Switzerland, *Quercus robur* in Poland, and *Picea abies* in Norway, all species that are also abundant in the Netherlands (Allen et al., 2010). Higher temperatures were also seen to be positively correlated to wildfire occurrence (Hawthorne and Mitchell, 2017), and models showed that in Canada the probability of unmanageable wildfire will increase (sometimes more than doubling) with the global climate models (Wotton et al, 2017).

In 2016 a record was broken for most burned forest area globally, with big wildfires in (among other countries) Brazil, Canada, Congo, Portugal and Indonesia (Peters, 2017). The year 2017 broke these records again in some regions (Editorial, 2017). For Europe, the IPCC calculated that extreme heat events will pose a medium to high risk for wildfires and livelihoods in the near future (IPCC, 2014). This is especially the case for southern and eastern Europe, which was showed by an application of the Canadian Fire Weather Index (FWI) to the European climate data. This model did calculate with 90% confidence that for western Europe there is a rising trend of FWI values over the years, showing that there are longer dry and/or hot periods (Venäläinen et al., 2014). The Dutch National Safety Profile 2016 (Nationaal Veiligheidsprofiel) acknowledges the risk of wildfire in the Netherlands as 'somewhat probable' with 'considerable damage' (RIVM, 2016). Global warming is thus also increasing the risk of wildfires in the Netherlands, which can pose a hazard for people close to areas susceptible for wildfire.

1.1 Wildland-Urban Interface

Wildfire management is often focused on the Wildland-Urban Interface (WUI), because (socio-)economic damage[1] very much increases when there is wildfire in the zone

[1] Physical, social, and economical damage are immediate close-by effects of wildfire (Champ, 2017). The adverse health effects of smoke can occur much further downwind of a wildfire (Vaidyanathan & Garbe, 2018) The total costs of the damage of wildfire is sometimes much

of overlap of nature and the lived environment (Van Gulik, 2008; Modugno et al., 2016). This Wildland-Urban Interface is the area where houses meet undeveloped wildland vegetation and where thus most of the environmental conflicts, such as wildfires, take place. In Spain it was seen that wildfire ignition occurs twice as often in the WUI compared to non-WUI wildfires (Chas-Amil et al., 2013). This makes the WUI also a priority area for wildfire prevention.

The concept of WUI was developed in North America where more and more people are attracted to live in the 'wildland'. It became important to structure debates about policy of these areas because in the WUI natural resource management and public policy meets (Stetler et al., 2010). The first definition of the WUI is that of the US Federal Register: 'the Wildland–Urban Interface is the area where houses meet or intermingle with undeveloped wildland vegetation'. The density of houses must be at least 6.17 housing units / km2 to count as WUI, and there is no defined maximum of houses (Radeloff et al., 2005). In Europe, different WUI mapping exercises have been carried out with modified definitions and classifications. The FAO definition is: "WUI is the transition zone between cities and wildland, where structures and other human development meet undeveloped wildland or vegetative fuels". Modugno et al. (2016) have transformed this to make a spatial definition of WUI: the overlap of buffer zones of 400m around fuel mass and 200m around artificial land. According to this definition in certain parts of the Netherlands there are many WUI areas, in which wildfire is a growing hazard. It is in these areas that the tension between safety from wildfires and room for natural processes occur most. An increasing risk of wildfires will drive the development of knowledge, policy and management for this risk in these areas.

1.2 Dutch forest and nature policy

Forest policy in the Netherlands has changed concerning the prioritization of values and functions of forests in recent decades. Forest policy was seen to go from forestry as an agricultural discipline to getting included into nature policy. This included a shift from mainly a single production function to balancing multiple extra functions: recreation, nature conservation and climate change mitigation function (Veenman et al., 2009; Arts et al., 2011).

Currently, Dutch nature policy and management firstly aims at expansion of forest area by linking the nature areas to each other into a network to increase the resilience and biodiversity overall (Arts et al., 2011; Ligtvoet et al., 2013). Networked nature does however increase the availability of fuel and thus the risk of uncontrollable wildfires.

A second forest policy is forest conversion, mainly focused on converting homogenous into more heterogeneous forests, with a diversity of layers and ages. This mostly concerns the exotic plantations with a (former) sole production purpose: they are often

higher than the suppression costs (Champ, 2017).

converted to multi-functional, multi-layered and multi-aged forests with mostly indigenous species (Geudens & Oosterbaan, 2011; Landelijke Vakgroep Natuurbranden, 2014). Still 51% of forest cover is coniferous (Probos, 2014). These concentrate in the South, middle and East of the Netherland, and in the dunes on the coast. Coniferous trees are generally more susceptible to fire than deciduous forests because of their lower moisture content per dry weight and the presence of resins (Päätalo, 1998; Stuiver & Verbesselt, 2011). It is therefore the expectation that having a more deciduous forest will result in smaller risk of uncontrollable wildfires.

Third, there is a move toward hands-off management with a minimal amount of interventions. Fewer interventions are made with the dual purpose of creating a 'wilder feeling' to the forest and giving more room for natural processes such as natural rejuvenation in smaller and more gaps in the canopy. A consequence of this trend is an increasing amount of dead wood that is left lying in the forest which is also a wildfire risk factor (Landelijke Vakgroep Natuurbranden, 2014).

These three trends of networked nature, forest conversion and hands-off management combined with global warming, impact the wildfire risk of Dutch forests (LVN, 2014).

1.3 Historical wildfire management

Historically, wildfire was an infrequent phenomenon in the low-lying European countries dominated by deciduous forests. The oldest known legislation against wildfires in the Netherlands dates back to 1554 (Jansen & Van Benthem, 2005) . In the 16th century in the Netherlands, controlled burning (see Box 1) was prohibited, just like building houses with roofs made of reeds or straw in forested or heath regions (Buis, 1993). From the times of the industrial revolution until the 1960s, forests were mainly seen as a resource, and thus wildfire was seen as an economic threat to be avoided or suppressed (Wilson et al., 2017). The big coniferous reforestations of heathlands in the 19th and 20th century led to more frequent big forest fires. This gave rise to the creation of forest compartments, either through clear-cut roads or by planting deciduous trees as fire break. In the Netherlands, Birches were mostly used in these so-called 'berkensingels' (Buis, 1993). Monitoring of the forest was set up, with watchtowers and later with patrolling airplanes on dry days. Also the wildfire suppression tactics improved because of better organization and professionalization of the fire departments during the 20th century (Stuiver and Verbesselt, 2011). In general, wildfire in the proximity of society has always been regarded as an unwanted and/or unnatural threat to forests, and was thus always prevented and suppressed if possible.

1.4 Current wildfire management

In 1985 the responsibility for wildfires was transferred from the special forest fire brigades to the municipal fire brigades. From that moment up until recently wildfire management was an extension of conventional firefighting, but in the last decade the

Dutch fire department started looking more closely into wildfires, by making wildfire risk assessments, starting a project group with the goal of developing a more fitting and tailored firefighting discipline, and piloting this new approach. Wildfire management, both preventive and offensive, contains often the multidisciplinary effort of actors from the public to private domains and national to local levels: the ministries, provinces, municipalities, safety regions, fire service, site managers, and the recreation sector (Infopunt Veiligheid, 2012).

Wildfire management, like regular fire management, is doctrinally split in three pillars: prevention, crisis management and the follow-up phase (see Box 1 for definitions). If wildfires do occur, crisis management mostly follows a fire suppression policy: extinguishing the fire as quickly as possible (Van Gulik, 2008; Brennan, 2016; Wilson, 2017, Van Engelen, 2018). Suppressing wildfires, effectively creating a wildfire exclusion policy, leads to the paradox that fuel (leaves and dead trees) accumulates in the forest, increasing the risk of larger and more damaging wildfires in the future (Van Gulik, 2008; Harris & Taylor, 2017; Wilson et al., 2017). Support for this hypothesis could be found in the amount of burned area by wildfires.

The amount and area of wildfires in the Netherlands has strongly decreased in the period of 1940 - 1995 (see Figure 1). After this period the statistics cannot be continued because they started to be collected in a broader category ('outdoor fires') than before, when they were categorized specifically as wildfires. Because of this, also the statistics of burnt area of the wildfires is not collected anymore, only the number of wildfires (Van den Heuvel, 2012). This means that there are no consistent statistics of wildfires in the Netherlands of the past 100 years. As an alternative source, an aggregation from news sources of the annual area burnt by wildfires shows that also in the last 20 years

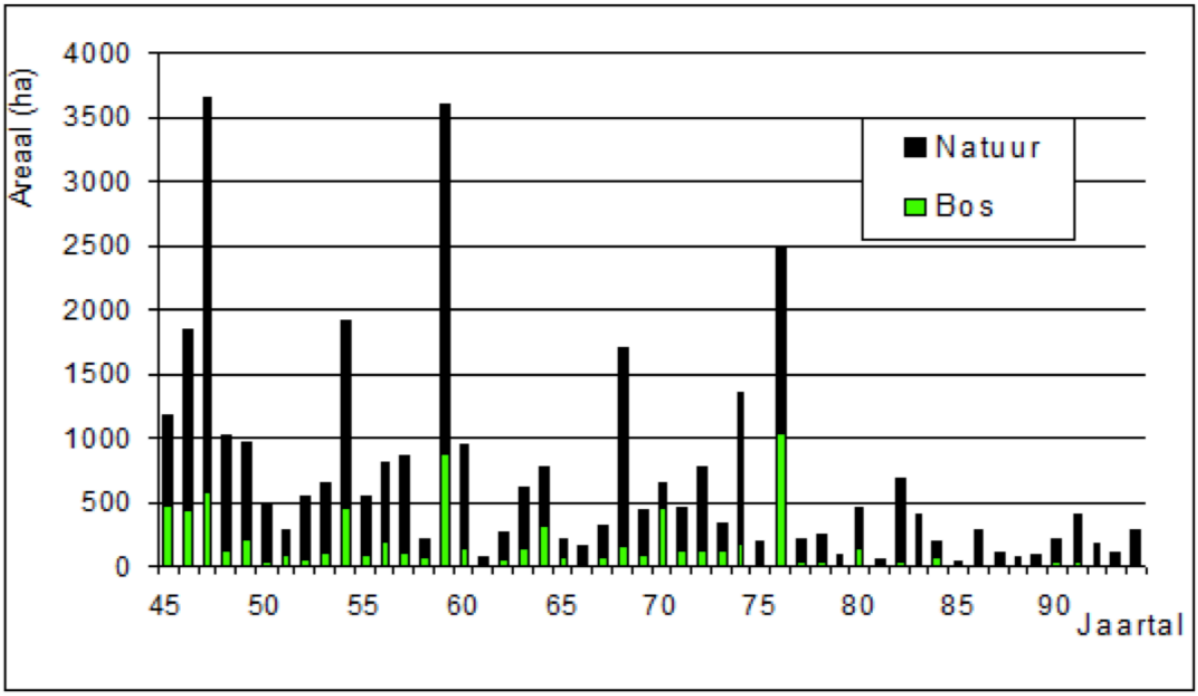

Figure 1: Area of burned forest (green) and nature (black) in the Netherlands, 1945-1994 (Jansen & Oldenburger, 2006)

there is no dramatic increase of wildfires compared to the mid-20th century levels (Boosten et al., 2009). But after 2009, there seems to be an increase again in the count and total area of reported wildfires (see Figure 2).

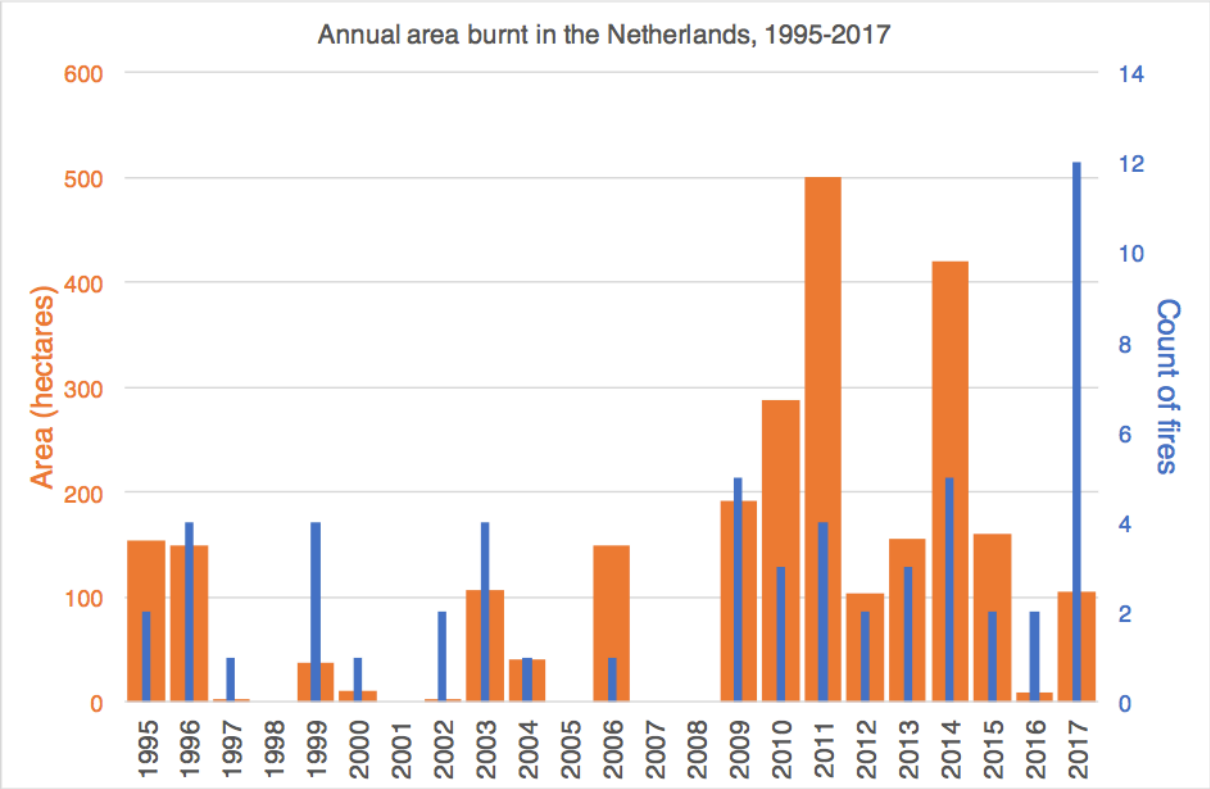

Figure 2: The total burned area and count of heath- and forest fires by year, collected from news sources. The gaps between 1997 and 2009 are probably due to poor searchability of news sources from this time. Raw data: Appendix 5: 'Wildfires in the Netherlands, 1995-2017'

Concluding, the current Dutch wildfire management is sufficient for suppressing wildfires and controlling the wildfire risk up till now. However, the downside of this policy is the accumulation of fuels in forests, which will increase risks when combined with climate change and the Dutch nature policy.

1.5 Objectives

We have seen that wildfire is one of the relevant climate change risks for the Netherlands. The Wildland-Urban Interface is the area where society is most likely impacted by these wildfires. Dutch forest and nature policy is more and more being impacted by the wildfire risk, but also increasing its risk by current management. Wildfire risk mitigation was formerly only a safety sector issue, but because of the increase of the risk it has currently gotten some overlap with nature management, creating an overlapping Venn-diagram of the safety sector and the nature management sector. The

Box 1: Definitions

Crisis management: The set of operations around a wildfire crisis that includes offensive and preventive wildfire management, evacuation, information systems, intelligence and command.

Offensive wildfire management: Taking measures that limit the extent, risk and impact of an actual wildfire.

Prevention: raising awareness of users, regulation through wildfire risk systems and (infra)structural interventions (Infopunt Veiligheid, 2012).

Controlled burning: Burning of a part of forest or heathland in a controlled way. If used offensive, it is called 'backfire', and aims to quickly take away the fuel for a wildfire (in Dutch this is called 'tegenbranden'). It can also be done preventive, to keep the general fuel load lower ('voorbranden').

Preventive wildfire management: Taking measures that limit the extent, risk and impact of a potential wildfire.

Follow-up phase: The phase in the crisis aftermath, which concerns the analysis of cause of the fire, (statistical) evaluation and repair of damage (Infopunt Veiligheid, 2012).

stakeholders in this intersection are the focus of this research. Now that they are operating in the same realm, whereas before this was not the case, three reactions could occur: firstly, their practices and policies could clash, creating conflicts and potentially damaging these. Secondly, they could also coexist: after familiarization they might tolerate each other, but not collaborate or enhance each other's practices. And lastly, they could integrate, creating essentially one adaptive wildfire policy, open to each others' viewpoints and using each other's expertise and ready for changing circumstances: a collaborative act of the nature management and safety domains.

Finding out which reaction is occurring, requires zooming in on three parts: firstly on the beliefs of the stakeholders about the wildfire risk, its relation to global warming and the role it should play in forest and nature management. If there is no general accord on this by stakeholders from both the safety and nature sector, a clash is probable, and more collaboration or integration improbable.

The second objective revolves around the presence or absence of collaboration between stakeholders of the safety and nature sector. Particularly, this study seeks to find the extent of sharing of information, expertise and experience between them, and what barriers there still are between them. When the barriers are bigger than the integration, the two sectors might end up only coexisting, tolerating each other, but not integrating into one adaptive wildfire policy.

However, when there is some measure of integration, it's this study's third objective to focus on the policy production process and the steps that are taken in the process of making an integrated wildfire risk management policy.

The results of this study will increase the knowledge about the Dutch nature and wildfire management and show its strengths and weaknesses. From this, improvements can be undertaken to come closer toward a sufficient wildfire risk policy. A further theoretical result might also be a better understanding of the relation between individual beliefs, intersectoral collaboration, and integrative policy development.

1.6 Research questions

What are the stakeholders' beliefs about the wildfire risk, and how are they collaborating in the policy production at the intersection of nature management and wildfire risk mitigation in the Netherlands, in particular with regard to the Veluwe?

Sub research questions

1. What are the stakeholders' beliefs about the wildfire risk?
2. How are stakeholders collaborating in management with expertise and experience, and what barriers are still there?
3. How is integrated wildfire risk management policy being produced by the stakeholders?
4. Is there a discrepancy between policies of nature management and mitigating wildfire risk?

Now that in this introduction the background of the problem, the objectives and the research questions have been put forth, the second chapter will give an overview of the theoretical frameworks used for the research, ending with a conceptual framework in which this is operationalized. The third chapter describes the methods, and the fourth chapter gives some context to the study. The fifth chapter is about the data collected, which is analyzed in the sixth chapter. The answers to the research question are formulated in the seventh chapter, the conclusion.

CHAPTER 2

Theoretical framework

The problem is examined through three different theoretical viewpoints. The first sub research question focuses on risk perceptions. This will be looked at from a risk society view. The second sub research question looks at the collaboration, information sharing and learning between stakeholders, which is an important determinant of adaptivity; therefore, part of the adaptive capacity framework will be used to answer this question. The third sub research question is about the policy that is actually being produced, and will therefore use a policy cycle framework for analysis.

These three theoretical frameworks will be described in the first three sections, thereafter this chapter will conclude with a conceptual framework which directs the theories toward the current research.

2.1 Risk society

Since in 1992 Ulrich Beck's book about 'risk society' was translated to English, this concept became increasingly popular, but its use has especially grown since 2005, especially in the social sciences, but also in the arts and humanities, environmental sciences and medicine (see Appendix A.2).

Beck coined the 'risk society' as opposed to the preceding 'industrial society' in which the governance of the production and accumulation of wealth was central (Matten, 2004). However, after all the modernization in the 19th and first half of the 20th century, society began to see the consequences of modernization: overproduction, waste, global warming, unemployment and individualization. At the same time, industrialization produced side effects that proved to be difficult to cope with (Matten, 2004). This resulted in a shift of governance: industry was limited by the risks of these consequences, because often these risks were uninsurable, and dislocated: global and thus not traceable back to one polluter (Beck, 1992). This development has resulted in a 'risk society' in which the production of wealth is coupled to the distribution of exposure to risk (Kiras, 2017; Lockie & Wong, 2017).

This then means that a risk society is occupied more with the governance of (environmental) risks than with the regulation of the sources of the (environmental) risk (Brulle and Pellow, 2006). When before, in times with genuine material need government was concerned with the (equal) distribution of productivity, now, in a time of need for safety, it is concerned with the equal channeling of risk as a result of this moderniza-

tion (Beck, 1992). For example, timber production was up until the 1950s the main subject of forest policy. In the last 40 years however, this has shifted more towards nature conservation, to protect the forests against economic and industrial risks, and also protecting society against these risks by conserving forest ecosystem services (Veenman et al., 2009).

Risk management and mitigation is now an organizing and culturally qualifying principle in society, instead of production (Bühler, 2017). When the past used to determine the present, now the future determines the present (Beck, 1992). When phenomena are characterized as risk in a risk society, they have to be controlled, by monitoring or containment (Moore and Reynolds, 2018) and the degree to which this is successful is a qualification for the society. At the same time, the traditional institutions and societal structures are also reflexively distrusted more than before, because they are seen as part of the problem and blamed for causing the risks (Pauly et al., 2015).

Climate change was not the main risk in Beck's mind when he wrote his thesis. However, his later writings show this development as the dominant global risk to which all humanity is exposed (Beck, 1999). He doesn't consider it, however, as a purely environmental crisis, but rather as part of the 'inner world of society', thereby crossing the border between the dualistic society vs. nature worldview (Bühler, 2017). This environmental risk is produced by the risk society and results in a new layering of social organization (Borne and Ponting, 2017). Society is now stratified by levels of impact of climate change. Often it is seen that lower-income groups are more exposed and vulnerable to climate extremes (IPCC, 2012). Inhabitants living under sea-level are faced with extra risk due to rising sea level, as are inhabitants close to rivers that need more capacity duo to growing peak run-offs. Inhabitants, visitors and users of forested areas too are faced with increased risk, due to higher risk of wildfire.

These societal effects also impact individuals. The globalization and knowledge interconnectedness leads to more risk awareness. People have to deal with an increased level of various hazards and insecurities (Stahl et al., 2017; Moore and Reynolds, 2018). Because of the complicated nature of the risks, they have to rely on experts possessing risk knowledge and assessment skills to make decisions based on costs and benefits balances (Nossek 2006; Knaak, 2010; Beck et al., 2014). In reaction to feeling perpetually insecure about the environment, behaviors are adapted with regard to calamities (Mustari & Karim, 2017). When before life was dictated largely by traditions, now people are expected to produce their own course of life based upon this adaptation (Orrnert, 2016; Moore and Reynolds, 2018). Because of the high-consequence risks, society starts to check and doubt the reliability of the expert-based system, even while the calamity that is feared has not happened yet. In this risk society which needs expertise, expert-based systems are reflexively doubted only because they are needed to identify the phenomenon as a risk, and because they could eventually cause a high-consequence calamity (Bühler, 2017; Mol & Spaargaren, 1997). This distrust of experts leads to the rise of alternative means of dealing with insecurities: decentralization and

public consultation, involvement and participation (Pauly et al., 2015). For this to happen, different framing of the global risks has to happen, through which different forms of action show up (Beck et al., 2014). Even though uncontrollable wildfires have not yet happened in the Netherlands, in a risk society this is not a reason to not change or create policy concerning wildfires.

An uncontrollable wildfire still is a small risk compared to the nuclear accidents about which Beck (1992) wrote. He defined risk in a context of extreme immediate catastrophic events associated with industrialization which, though their probabilities are low, pose a threat with highly destructive and unimaginable implications. The call Beck makes in relation to the risks he had in mind is the same for this risk: society has to weigh the costs and benefits. Creating long-term ecological health costs some short-term economic interest (Wilson et al., 2017). Compared to other risks, the wildfire risk is currently not given much priority in policy and management, although awareness is rising (Van Gulik, 2008; RIVM, 2016).

In the next section, we will zoom in on this policy and management, by looking at a theoretical framework used for analyzing the adaptive capacity of institutions.

2.2 Learning capacity

To mitigate the potential consequences of climate change, of which wildfire is one, adaptation is needed in society. A risk society focuses on (economic) resources, technology, information, expertise and infrastructure, but important determinants of societal adaptive capacity are also the roles of institutions, governance and management (Mandryk et al., 2015; Engle, 2011). Institutions are social patterns, including organizations, actually any form of collective action can be seen as institutions. Institutions provide stability and predictability, but this means that they react incrementally and conservatively to change (Gupta et al., 2010). Adaptive capacity is the degree to which institutions are able to respond to a change, for example climate change or an increase in wildfire occurrence. Institutions need to learn this, and adjust to it, requiring vulnerability but also resilience (Engle, 2011). Responses can be preventive: adapting is sustainably changing to be better prepared for long-term future risks (IPCC, 2012), but they can also try to moderate the damage or take advantage of new opportunities (Gupta et al., 2010). If current circumstances are increasing in variability, institutions are forced to be more proactive and flexible (Thornton et al., 2014).

Gupta et al. (2010) designed an analytical tool to assess the adaptive capacity of institutions to cope with climate change: the Adaptive Capacity Wheel. This wheel captures important qualities of institutions which enable climate change adaptation in the image of six dimensions: variety, learning capacity, room for autonomous change, leadership, availability of resources and fair governance (see Figure 3). The first three

of these six can be viewed as core qualities of an adaptive institution, and the other three as supporting external qualities that support the quality of an adaptive institution (Termeer et al., 2012). While an adaptive institution is built only by the three core dimensions, its adaptive capacity can only be turned on by the supporting dimensions. Some authors find this approach lacking the human factor of institutions, and counterbalance this by adding the dimensions of 'adaptation motivation' and 'adaptation belief' as factors of human capital contributing to the adaptability of institutions to climate change (Grotholt, 2017).

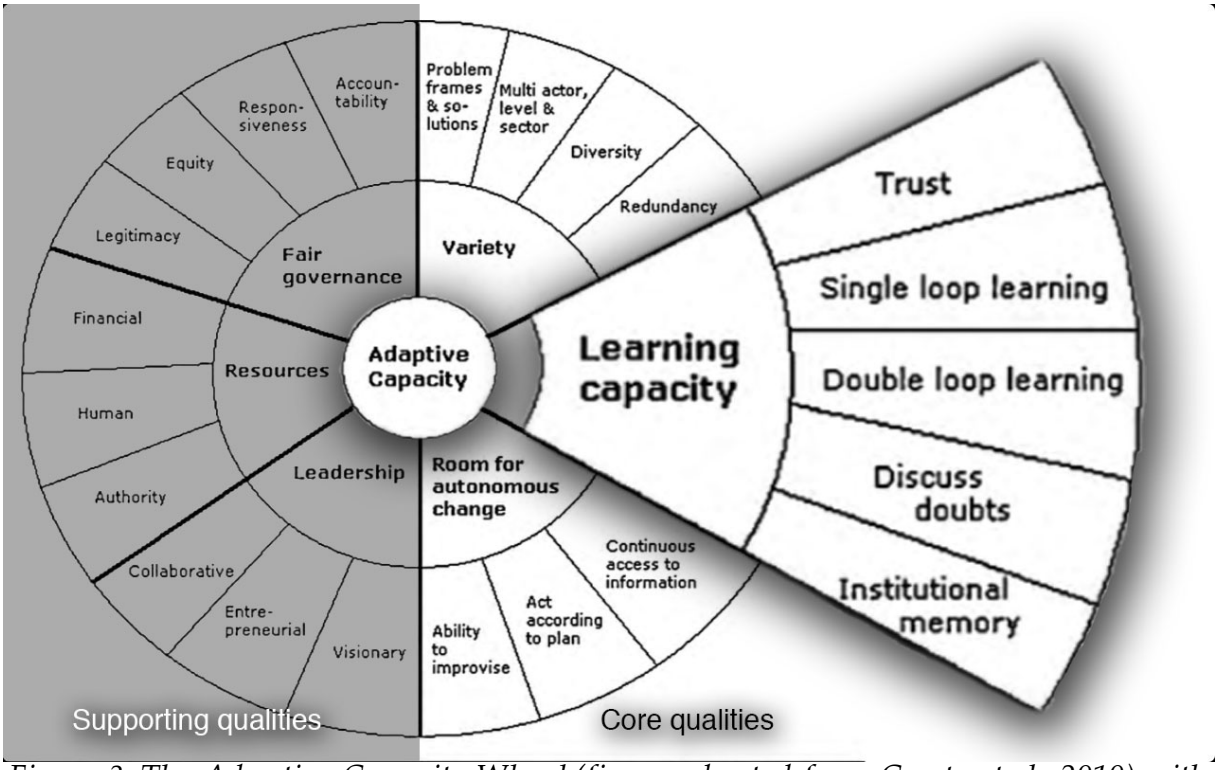

Figure 3: The Adaptive Capacity Wheel (figure adapted from Gupta et al., 2010) with the Learning capacity dimension enlarged. The inner ring show the six dimensions, and the outer ring their criteria. On the grey background are the supporting qualities, on the white the Core qualities (Termeer et al., 2012).

The impacts of climate change are already happening, therefore a learning approach to policy and governance is required to learn from past experiences and incorporate new information into practice (Bosomworth, 2015, Bergsma et al., 2012). This learning capacity, including communication about and reflection on past actions and motives, also called social learning, can inform the direction of policy to which an institution should turn (Bettini et al., 2015). This enabling to learn and improve is necessary to institutions promoting adaptive capacity and will be beneficial for mainstreaming climate adaptation (Gupta et al., 2010; Grotholt, 2017).

Gupta et al. (2010) constructed five criteria to measure the presence and relative amount of learning capacity in institutions which can be assessed and scored or color coded to quantitatively compare institutions. Firstly, trust: the presence of institutional

patterns that promote respect and trust inside an institution and to the outside. When decisions of organizations are not supported at least of the individuals inside an organization, adaptive capacity is weakened (Sapkota et al., 2018). An indicator for trust is internal and external collaboration, because collaboration presumes at least a contractual trust in the opponent.

Secondly, single loop learning is the ability of institutions to learn from past experiences and improve its practice and routines. These are incremental improvements of the present routine, so the policy is adjusted when the practice meets an unexpected reality, but it stays locked in the dominant frame (Grin & Loeber, 2007; Pahl-Wostl et al., 2011; Bosomworth, 2015).

The third criterion is double-loop learning. Double-loop learning goes a step deeper than single-loop learning in which only the practice was reconsidered (Pahl-Wostl et al., 2011). It is the effort inside an organization to investigate and challenge embedded frames, philosophical ideas, assumptions, claims, roles, rules, identities and policy goals underlying institutional patterns (Klostermann et al., 2009; Termeer et al., 2012 and Bosomworth, 2015). By doing this, more room is created for changing to different circumstances in which the organization can be found. This happens for example when an institutional crisis or reorganization occurs, because the organization is then forced to reconsider its identity (Bettini et al., 2015).

Fourthly, discussing doubts is the institutional openness towards uncertainties, not a defensive attitude, but instead almost skepticism, about its policies, instruments and routines (Hurlbert & Gupta, 2017). It can be a consequence of double loop learning, because it requires a critical thinking about the frames through which the institution operates (Pahl-Wostl et al., 2011). Adaptive institutions would be, for example, modeling or experimenting with uncertainties (Termeer et al., 2012; Bettini et al., 2015). This step is dependent upon trust internally and externally, because it makes the organization quite vulnerable.

And lastly, institutional memory is important: the retention of knowledge of monitoring, evaluations of policies and routines, ready to replicate successful solutions (Gupta et al., 2010, Bergsma et al., 2012). It is the memorization of the institutions' practice, so that it can become routine, but also of the incremental adaptations that are made in single-loop learning. Bergsma et al. (2012) found that an open and informally structured steering group didn't enhance institutional memory, since the past history is then not recorded. When the past history is truthfully and consistently recorded and shared it can also feed back positively in internal trust. So this indicator shows that some aspect of institutionalization is actually important for adaptive capacity.

Gupta et al. (2010) argued that the Adaptive Capacity Wheel doesn't indicate the elements that lead to a higher adaptive capacity. Rather, it measures the effect of the institutional adaptive capacity in a social context (Bergsma et al., 2012). Grotholt (2017) made another approach to measuring learning capacity and added to the former five

indicators, which he put under 'social learning', the condition of 'information resources'. This condition ensures that content is generated for the adaptive policies, while social learning ensures that the right institutional attitude for adaptive policy is present (Grotholt, 2017).

In an application of the adaptive capacity wheel, Klostermann et al. (2009) found that nature protection institutions showed the weakest adaptive capacity compared to climate, water and agriculture institutions. One explanation of this lower adaptive capacity is that 'conservation' is often central in these nature protection institutions. Conservation is in itself the institutionalization of history, which is contradictory to adaptation (Gupta et al., 2010). This is not say that the conservation organizations have a conservative character too, but it might be a correlation between the conservation and climate, water or agricultural institutions. Another notable finding was that the decision making in these conservation institutions is often left only to ecological experts, and not in an open debate with more stakeholders (Klostermann et al., 2009). This heavy reliance on experts was also one of the institutional weaknesses that Termeer et al. (2012) found. They saw that institutions with weak adaptive capacity showed, among others, "lack of openness towards learning and variety, strong one-sided reliance on scientific experts and tension between top-down policy development and bottom-up implementation" (Termeer et al., 2012). These common problems are weakening adaptive capacity because they harm the institutional trust and double loop learning.

The Adaptive Capacity Wheel entails the dimensions of learning capacity, variety, room for autonomous change, leadership, availability of resources and fair governance (Gupta et al., 2010). These are all important indicators of a larger adaptive capacity, which enable organizations impacted by the higher wildfire risk to better adapt to the changing circumstances. This research will only look at the learning capacity, because that dimension focuses most specifically on the collaborative character of organizations that are adaptive and on the practice development and policy production inside organizations.

Not only is the adaptive capacity of institutions interesting for investigating how the wildfire risk is dealt with in the Netherlands, it is also worth zooming more in on the policies itself that are produced in the wildfire risk mitigation process. One of the ways to this is through the policy cycle analytical tool.

2.3 Policy cycle

Policies take time to develop, so even though from the outside it might seem that wildfire risk is not given much priority in policy and management, there might nonetheless be development around it. To zoom in on the progress of this policy development, the policy implementation cycle is a useful tool.

The policy cycle conceptualizes the process from issue recognition to policy being implemented into management, breaking it down into stages, that differ between authors and cases. Krott (2005) described the forest policy analysis around two core stages: policy formulation and implementation, preceded by agenda-setting and concluded by evaluation and termination. Other authors extend the cycle by adding the stages of legitimation or decision making after the policy formulation (Jann & Wegrich, 2007; Sabatier, 2007). A more recent author constructed a slightly different cycle by adding stakeholder consultation after the agenda-setting and formal approvement by the authority before implementation as stages. The author also emphasized that evaluation should happen during all stages (Kaomunangnoi, 2014). Three different cycles with their mutual differences can be seen in Figure 4.

From these three different cycles the following seven stages can be distinguished hypothetically relevant for the current research. Approvement has not been included as a separate step (as done by Kaomunangnoi, 2014), since it was not found with other authors as a separate step, is in the Netherlands not more than a formal step and is not expected as problematic in the implementation of wildfire risk mitigation policy.

1. Agenda-Setting The issue is recognized as a societal problem to be solved, and objectives for this are drawn up (Krott, 2005; Jann & Wegrich, 2007).
2. Stakeholder consultation Possibly involved or affected stakeholders, local people and the at-risk population are consulted about the issue being on the agenda, for input on solutions or for participation in the policy formulation (Krott, 2005; Wilson et al., 2017).
3. Policy formulation Objectives for (alternative) policies addressing the issues are described clearly.
4. Decision-making between alternatives The proposed polices are compared, and one is chosen based on costs, benefits and impact analyses (Jann & Wegrich, 2007).
5. Implementation of the policy is the problem-solving phase in which the program as intended by the government is applied in the field (Krott, 2005). This phase is important to consider because often the action is not perfectly in line with the intention, but distorted, delayed or blocked. Ideally, implementation involves the specification of program details and the allocation of budget and/or personnel (Jann & Wegrich, 2007). The regulatory bodies should be supported or maintained for continuation of the policy (Kaomuangnoi, 2014), which is in some frameworks mentioned as a separate stage in the policy cycle.
6. In the evaluation stage the focus is on effectiveness, efficiency and comparing the intended outcomes of the policy with the (unintended) consequences it has made through the program. With this information the program is either terminated or redesigned (Jann & Wegrich, 2007).
7. Termination If a program is ineffective or inefficient for reaching the objectives, it should be terminated, to prevent wasting resources and to make room for new policy.

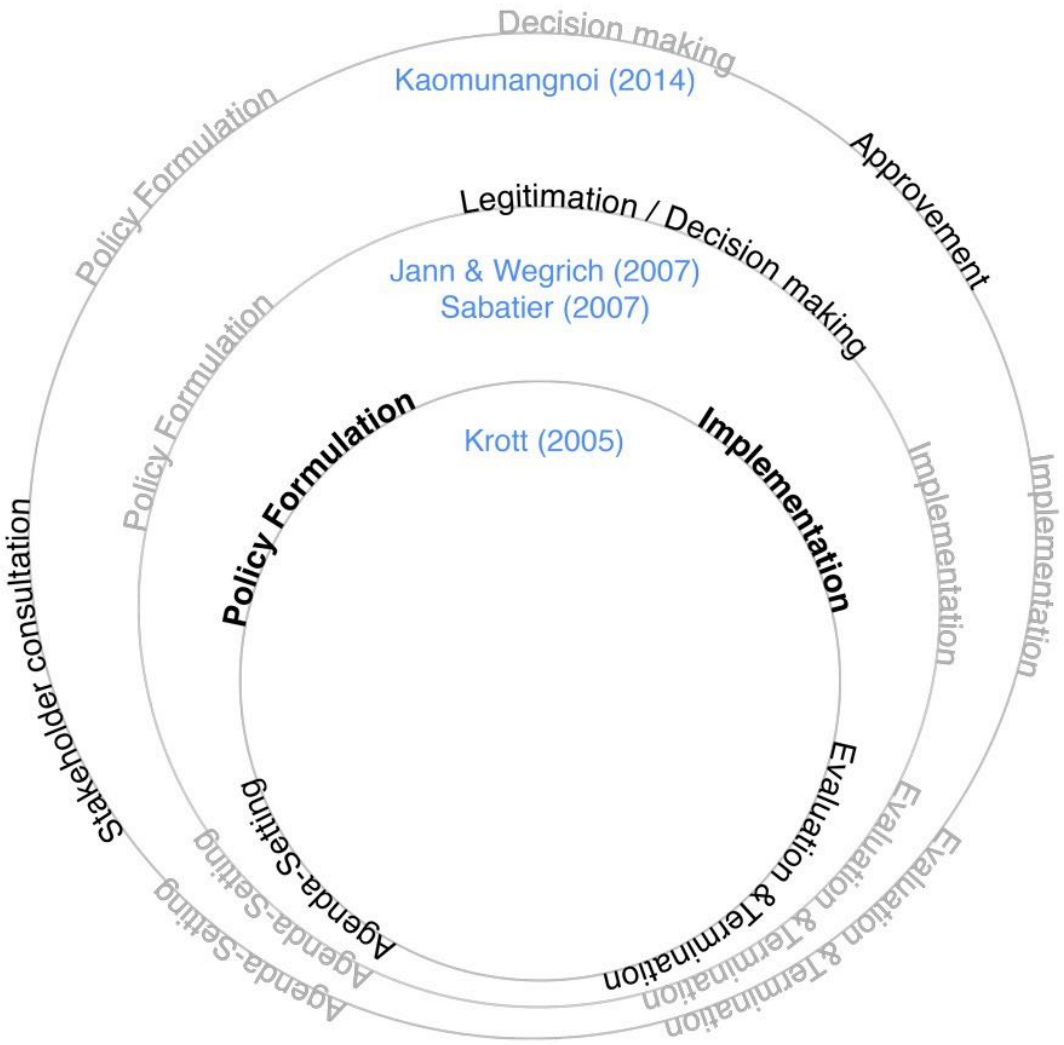

Figure 4: Differences between three policy cycles, starting in the lower left and going clockwise. Krott (2005) has the two core stages in bold. Jann & Wegrich (2007) and Sabatier (2007) add legitimation / decision making (in black). Kaomunangnoi (2014) adds stakeholder consultation and approvement (in black).

This stages, or 'heuristic', approach belongs to the family of rational policy analysis. These take the rational-strategic actor as starting point. The stages approach or policy cycle model assumes that the collective of actors is able to design effective policy based on science and rationality (Arts, 2012). In the Dutch context of collective governance, the 'poldermodel', this is an appropriate assumption, because often stakeholders negotiate and compromise to reach consensus. The stages approach is also actor-material oriented, assuming individual agency, self-interest, rational calculations and methodological individualism (Arts, 2012).

Although the policy cycle is much used to structure research, it is also paradoxically much criticized, for a few reasons (Fischer et al., 2007). The number, order and equality of these seven stages is not as fixed as the cycle implies. Some analysts add stages or

change the order. In some policy cases, some stages are even skipped, completely or partly (Howard, 2005). This raises the question if there really is an analytical difference between the stages, and if this is deduced from empirical data or just induced from theoretical elaboration. The same could be said about the sequence, since some of them could easily be shuffled or run parallel to each other (Jann & Wegrich, 2007).

Another point of critique is the shortcomings of this model in relation to its top-down approach, in that the cycle assumes the steering of the process. And finally there is a critique about the omission of the personal and political opinions that stakeholders bring to the discussions that occur in all the stages, as if those would not be a big influence on the stages and policy development (Jann & Wegrich, 2007). Other approaches try to mend these shortcomings, for example the network approach, interactive approach and the pluralistic approach (Rotmans et al., 2005).

All these criticisms raise the question of this theory's usefulness. The main value of the policy cycle is methodological; despite the mentioned defects it has proven to create a useful structure in policy research for analysis of policy development processes and research inside its particular stages (Jann & Wegrich, 2007). It should not be used as a hard planning tool for policy development, but rather as a set of important properties of policy development, which is also the way in which it will be used in the current research. In a heuristic assessment of policy development, these seven stages should probably be distinguishable, although their causal relationships might be less linear then this model implies.

2.4 Conceptual framework

Using the theoretical framework for analysis of the data in this research requires a conceptual framework of criteria and indicators. For the current research, the theoretical framework of risk society is used to point to typical societal trends concerning wildfire risk perception and be thus connected to the first sub research question. From the framework of adaptive capacity, the dimension of 'learning capacity' will be used to look at the trust, collaboration and attitude of stakeholders toward other organizations and changing policies, for the second sub research question. The policy cycle will be applied to describe in which stage wildfire risk mitigation policy development currently is, and be used in the third sub research question. The fourth sub research question is an analytical question that uses the results of the previous three research question.

Risk beliefs

Concerning risk society we look for eight indicators (see Table 1). These indicators mainly serve the first sub research question by providing information on the stakeholders' beliefs about the wildfire risk, and if these beliefs might be explained by the

risk society theory.

From the risk society discussion in chapter 3.1, four characteristics of a risk society can be distilled. Firstly, the fact that risks become an important subject in policy making (Beck, 1992). Secondly, expertise is being developed with the goal of controlling and mitigating the risk (Beck et al., 2014). A third characteristic is that risk mitigation becomes a qualifying principle in society. Lastly, with regard to risk perception, a risk society is especially concerned about risks that are deemed to be too big to control (Beck, 1992). These four characteristics are developed into the eight indicators of Table 1.

Criterion	Indicator #	Indicator
Risk prioritization	1	Different risks are weighed and prioritized concerning resource allocation. For example: No wildfire risk mitigation because there's not enough money, or because there is no room in policy for it.
	2	Wildfire risk management is prevalent over productivity or nature functions.
Expertise development	3	Knowledge of wildfires is developed, shared and expanded.
	4	There are conferences / meetings between stakeholders.
	5	Expertise is used to facilitate risk communication and prioritization.
Risk mitigation as culturally qualifying principle in society	6	There is policy development concerning uncontrollable wildfires. Even though these have not yet occurred in the Netherlands.
	7	The wildfire risk mitigation measures are features about which is externally communicated or upon which areas are identified by the public.
Risk perceived as uncontrollable	8	The wildfire risk is inflated by society, described as too big to control, and the responsible actors are hard to pinpoint.

Table 1: The eight indicators derived from the risk society theory.

Learning capacity

From the theoretical framework of learning capacity, six indicators are constructed to

substantiate the second sub research question, which deals mainly with the stakeholders' collaboration (see table 2). Five of these (numbers 10-14) are corresponding to the five indicators that Gupta et al. (2010) have defined. Indicator #9 is added to measure the amount of collaboration, because that is both an indicator of trust (Bergsma et al., 2012) and a research objective in itself.

criterion	Indicator #	Indicator
Trust	9	There is collaboration or an exchange of information between stakeholders.
	10	There is respect and trust towards other stakeholders.
Single loop learning	11	(Actors in) institutions learn from past experiences and improve their practice.
Double loop learning	12	Actors investigate and challenge embedded presuppositions underlying their (organization's) practice.
Discuss doubts	13	There is openness about uncertainties in the stakeholder's (organization's) practice or policy.
Institutional memory	14	Lessons learnt or experiences are reported for future use (Grotholt, 2017).

Table 2: Six indicators of the presence of learning capacity in interviewees.

Policy development

From the theoretical framework of the policy cycle, seven indicators are constructed to help answering the third sub research question (see Table 3). The seven stages that were described in chapter 3.3 are each accompanied by one indicator.

criterion	Indicator #	Indicator
Agenda-Setting	15	The wildfire problem is in consideration for public action by being put on the agenda.
Stakeholder consultation	16	The stakeholders affected by the interventions are involved with the policy-making or at least consulted about the interventions.
Policy formulation	17	Clear objectives concerning the wildfire problem are described.
Decision making between alternatives	18	Different alternatives for wildfire risk mitigation programs are elaborated and subsequently fairly compared.

Implementation	19	The chosen program is implemented according to specification and budget by contractors / stakeholders.
Evaluation	20	There is a regular evaluation of the policy implementation and results.
Termination	21	Ineffective programs are terminated. Mention is made of unsuccessful and terminated attempts of policy.

Table 3: The seven indicators derived from the policy cycle theory.

CHAPTER 3

Methodology

This research is based on a single case study in a cross-sectional approach, studying some embedded actors (De Vaus, 2001). This approach made it possible to zoom in on a certain part of the Netherlands, and get a more thorough understanding of the issue in one place. From this, certain insights concerning wildfire risk mitigation might emerge, but practical generalization is not directly possible toward other regions (Kumar, 2011). However, the findings concerning the policy processes and collaboration might be applicable to other environmental-governmental conflicts.

Wildfires occur most on the higher, drier sandy soils in the Netherlands, the dunes, and in parts of the South and West of the Netherlands (Stuiver and Verbesselt, 2011). In these regions there might also be much experience, expertise and policy development concerning wildfires. The central part of the Veluwe contains the biggest continuous nature areas in the Netherlands: the Kroondomein Het Loo and the NP De Hoge Veluwe. The presence of these and more natural areas with heathlands and forests on high, dry sandy soils[1], combined with some residential areas and cities, important infrastructural functions and a high risk indication make the Veluwe a good case for this research.[2] This methodology chapter will discuss the methods, and how the data is analyzed.

3.1 Interviews

This research has a qualitative approach with semi-structured interviews. The choice for a qualitative approach was informed by the fact that it was not the objective to compare multiple institutions (Gupta et al., 2010), but to explore the learning capacity that was present in the stakeholder network, the perception of and action about the wildfire risk of the embedded stakeholders and the advancement of the policy production in this regard (De Vaus, 2001). A general public and tourist survey about perception of wildfires has been carried out by Brennan (2016). The present study has the complementary objective to look at the safety and nature sectors, where policy concerning the natural areas is made and implemented.

In the present study, the identification of the appropriate stakeholders to interview was carried out in an iterative manner in which during the research, more stakeholders were found and interviewed, also known as snowball sampling (Kumar, 2011: p.208). This avoided the disadvantage of beforehand choosing interviewees without knowing

[1] see Appendix A.6
[2] See Chapter 4 for a description of the Veluwe as a case.

the playing field in which the important stakeholders were located.

To get a complete picture in the current study, it was important that the interviewed stakeholders were from different sectors: nature policy, terrain management and public safety sector. Interviewees were found by contacting organizations and individuals by email, and their recommendations during the interviews were also used for the further identification of interviewees. A stakeholder analysis about responsibilities in case of wildfire on the Veluwe (Van Raffe, 2011) already determined a comprehensive set of stakeholders (Appendix A.1) as a starting set. Eight interviews were held, and three more organizations were approached, but were unavailable for interviews or referred to other organizations.

The data were gathered through semi-structured interviews. A semi-structured approach of interviewing ensures that all necessary topics are covered and that freedom is still left to specify the conversation to the stakeholders' situation (Kumar, 2011). The exploratory nature of the study made fully-structured interviews with pre-formulated answers less suitable, even though that would make more valid analysis possible.

The interviews were structured along the lines of three topics, based upon the research questions, which weren't strictly discussed in this order but were present in all interviews. Firstly, about the incorporation of risks of uncontrollable wildfire into Veluwe nature management. This topic covered environmental policy, nature management, safety protocols, experience building from other wildfires, barriers and differences between the safety and nature sectors. The second topic focused more on the individual perception of the interviewee regarding wildfires. This perception involved climate change, the relation between wildfires and climate change and the risk of wildfires for the Veluwe particularly. The third topic focused on what the stakeholders had done with the wildfire risk. This could for example be risk communication or adapted wildfire management, both preventive as offensive.

All interviewees were Dutch and the interviews have been carried out in Dutch. The translated interview guide can be found in Appendix A.3.

Interviewees

Eight stakeholders concerned with the wildfire risk on the Veluwe were interviewed, both terrain managers and safety sector bodies, both public and private (see Table 4). Staatsbosbeheer is less public, since it is privatized, but not completely: it still executes a governmental task. The NP De Hoge Veluwe is more private than other national parks in the Netherlands since it doesn't get funding from the government but funds its running costs mainly through entrance fees. Kroondomein Het Loo is a private estate, though part of it (palace Het Loo) is state-owned, and the Kroondomein Het Loo (the forests) are on loan to the state. Each interviewed stakeholders will be described further below.

The groups as outlined in table 4 were used for analysis as the main unit: public terrain managers, private terrain managers and the public safety sector.

	public	**private**
terrain managers	Staatsbosbeheer Ermelo municipality Harderwijk municipality Rijksvastgoedbedrijf	Kroondomein Het Loo NP De Hoge Veluwe
safety sector	IFV VNOG	

Table 4: Three groups of interviewed stakeholders, divided by the sector and nature differences.

VNOG
VNOG is short for Veiligheidsregio Noord-Oost Gelderland, one of the 25 safety regions. This 'safety region' is a partnership of safety organizations: police, fire department, health organization and crisis management. The fire departments, with the belonging local fire brigades, are part of the safety region. In this organization Arnoud Buiting was interviewed, project leader of prescribed burning. This was an interview with two interviewees, the second being Ester Willemsen (working for IFV), project leader of GEO data and national coordinator of the specialism Wildfire Management.

IFV
The Instituut for Fysieke Veiligheid is supporting the safety regions through expertise development, scientific research, special equipment and education and certification of fire fighting officers. They also develop the wildfire fighting expertise. Hans Hazebroek was interviewed, he is researcher-advisor firefighting for large-scale incidents.

Kroondomein Het Loo
The royal estate of Kroondomein Het Loo is the biggest estate of the Netherlands, spanning more than 10.000 hectares. It is in the mid-north of the Veluwe, north-west of Apeldoorn. The area contains ±8000 hectares of forests, with various functions: nature reserves, multifunctional forest and production forest. The rest of the area consists largely of heathland, some sand drifts and 6 hectares of agricultural area. Tieke Poelen, one of three terrain managers, was interviewed. He has been working for 30 years in the Kroondomein Het Loo, and has formerly been manager for Staatsbosbeheer.

Staatsbosbeheer
Staatsbosbeheer manages the largest amount of terrain in the Netherlands, by order of the national government. Formerly a state company, it is since 1998 a RWT ("rechtspersoon met een wettelijke taak", a legal entity with a task laid down in law), so a privat-

ized company with a government task, and also funded by public money. On the Veluwe Staatsbosbeheer manages ±20.000 hectares of nature area. Willem van Ark was interviewed, having been the wildfire management specialist for all of the Veluwe's forests of Staatsbosbeheer between 1998 and 2016.

NP De Hoge Veluwe
NP De Hoge Veluwe has 5400 hectares of nature, of which 2000 hectares of open heathland. It lies in the municipality of Ede, and is located between Hoenderloo, Otterlo, Arnhem and Ede. It houses some cultural-historical elements, such as a big hunting lodge and an internationally renowned museum of art, the Kröller-Müller Museum. Jakob Leidekker was interviewed, chief operational management, responsible for the terrain management (forest, heathland, fauna, buildings, infrastructure and bicycles). He works for the NP De Hoge Veluwe since 2004.

Ermelo
Ermelo is a municipality in the western part of the Veluwe, south of Harderwijk. It has 1800 hectares of natural terrain, of which 1000 hectares is heathland, divided into three separate terrains. Henk-Jan Zwart was interviewed, he is chief manager of the natural areas.

Harderwijk
Harderwijk is the municipality north of Ermelo. It has 1600 hectare of natural and agricultural area, of which 800 hectare is forest, 75 hectare of heathland, and 95 hectare of sand drifts. Roel Janssen was interviewed, the manager of rural area of Harderwijk.

Rijksvastgoedbedrijf
The Rijksvastgoedbedrijf is the government organization managing the state's real estate, so all buildings and areas. Military training areas make up a big part of the total area: ±25.000 hectares in the Netherlands. The interview dealt mainly with the ASK (3900 hectares) and ISK (2500 hectares). The ASK is a shooting range for large artillery units, and is located in the north of the Veluwe, between Nunspeet, Wezep and Epe. The ISK is the shooting range for infantry units, located adjacent to NP De Hoge Veluwe, between Harskamp and Hoenderloo. From the Rijksvastgoedbedrijf, Frans Borgonje was interviewed, chief of the section Nature management.

3.2 Analysis

Transcripts of the interviews were checked with the interviewees to check if what they wanted to say had transpired correctly in the transcript. After transcription and verification with the interviewees, the data was first put through a single round of initial coding. Initial coding is based on the raw data: assessing the texts on the concepts that are talked about, and creating codes for them (Reed, 2008; see Figure 5).

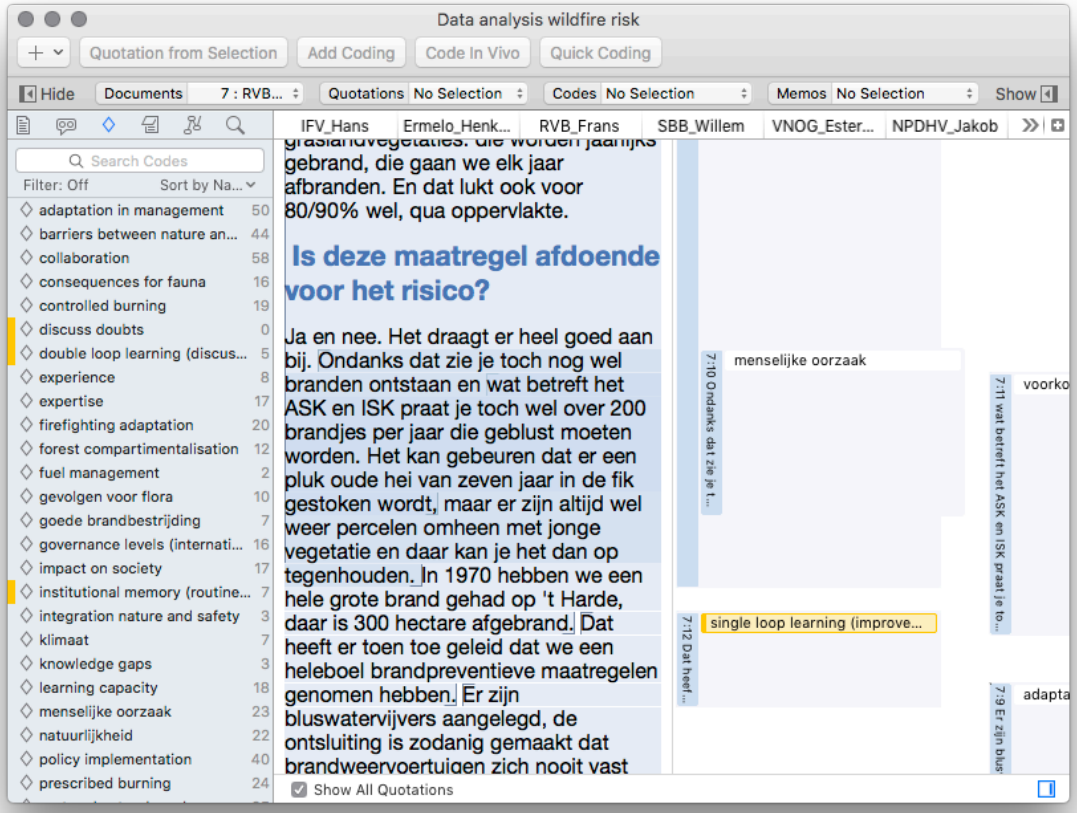

Figure 5: Screenshot from the initial coding process of Dutch interviews in Atlas.ti software. The left is part of the list with initial codes, the middle the transcript and the right column indicates what part of the transcript is coded.

The second round of coding, selective coding, then sorted the initial codes into categories, in this research the research questions. After this step an outline was created with the categories as headings and the codes as subheadings, and the referenced parts of the text were translated and sorted below the headings (Charmaz, 2008: 163). This data was analyzed through the indicators, by close examination of the data and giving points to the indicator if supporting fragments were found, and subtracting points when contrary data was found. This score was then standardized per indicator to a score between -4 and 4, and displayed with arrows (see Table 5).

Values	< -2	≥ -2 and < 0	0	> 0 and ≤ 2	>2
Symbol	↓	↘	→	↗	↑

Table 5: The symbols belonging to score classes.

CHAPTER 4

Context of study

4.1 Veluwe

The Veluwe is a central natural region in the Netherlands with multiple functions: nature, recreation, living, working. Because of this there is a large network of public, private, (sub-)national and local stakeholders and organizations impacted by the risk of wildfire. Its geographical and administrational boundary is best described by the COROP region 'Veluwe' which only excludes part of the municipality of Arnhem that belongs to the geophysical unit of the Veluwe (see Box 2).

The risk of wildfires for society are foremost localized in the Wildland-Urban Interface (WUI). The definition of the WUI is that includes the intersection of a border of 400 m around forest or dry nature areas and of 200 m around built structures (Modugno et al., 2016). Many areas on the Veluwe fit this definition[1], mainly (edges of) small towns and campings (Radeloff et al., 2005; Brennan, 2016, see Figure 6). There are around 15 towns in the forested area with up to a few thousand inhabitants. The populations of these towns including their campings often increases tenfold in the peak of the tourism season, when 1.8 million people stay in the area (Van Gulik, 2008; VisitVeluwe, 2016). The Veluwe is not wildland by biophysical definition, since it has in past times been cultivated area and is now managed by creating the conditions for some 'wild' natural processes. It does fit the definition of wildland, however, when it is fit into the frames of wilderness as area of 'promise or danger' where unexpected beauty or risk can be encountered (Arts et al., 2012). Considering that nature management of parts of the Veluwe is such that risks for people using the area are not minimized also supports the view of Veluwe as wildland (Van Gulik, 2008).

[1] The formal definition of the Wildland-Urban Interface is not really applicable to the Netherlands, since technically not any part of the area is 'wild land' in the sense of undeveloped natural area. For that reason, Van Gulik (2008) uses the concept of Urban-Rural Interface (URI) instead for the Veluwe. However, to comply with the large English scientific research body, this study will use WUI to talk about Dutch natural areas with private properties or towns (close-by).

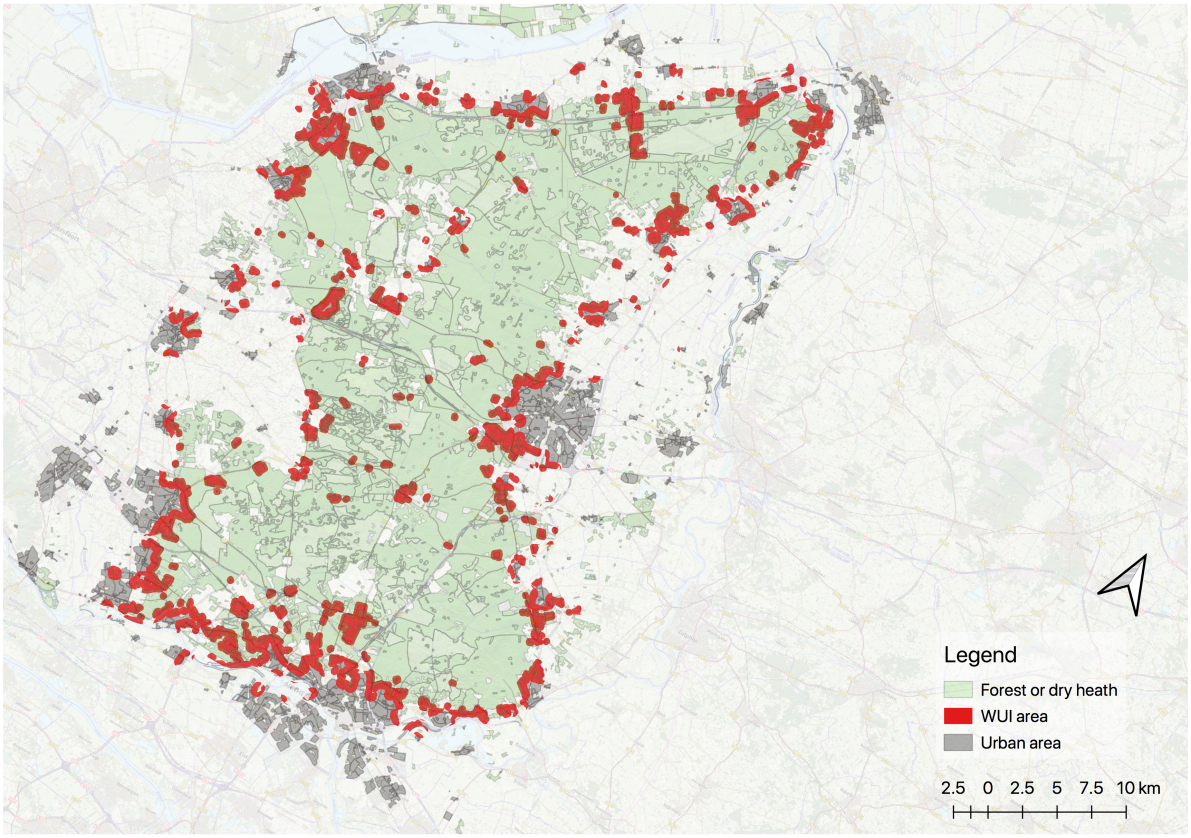

Figure 6: WUI areas on the Veluwe. In red is the intersections of a 400 m buffer around forest/ dry nature areas and 200 m buffer around buildings.[1]

The now forested areas of the Veluwe began to be cultivated on a large scale in the 19th century, mainly with fast growing Scots pine. In the first half of the 20th century also other coniferous species were introduced, such as Douglas spruce, larches, other pine species and Norway spruce. In the second half of the 20th century, deciduous species were getting more priority again, but still 60% of forested area in Gelderland currently consists of coniferous species, and 43% is specifically Scots pine (Oldenburger et al., 2017, Schelhaas et al., 2014).

Apart from its functions as nature area, for tourism, and people living there, there is also critical infrastructure. 4 highways and 3 passenger railways connecting cities on all sides of the Veluwe cross it. There is also much agricultural land and it has a few military training areas (Brennan, 2016; LVN, 2014).

A risk assessment specifically on the relatively dry and forested region of the Veluwe calculated the risk of wildfire 'probable', and its impact 'very high' (VGGM, 2015). The current chances of an uncontrollable wildfire on the Veluwe are 4%, and 50% on dry days (Van Gulik, 2008; Schelhaas and Moriondo, 2007). A dry day is determined by having a dryness-index[2] higher than 55; between 1994 and 2007 the average number of dry days in the Netherlands was 30 per year, with the expectation that this number

[1] Sourcedata of area use: CBS (2012) *Bestand Bodemgebruik*.
Backgroundlayer: J.W. van Aalst, www.opentopo.nl

[2] The 'dryness-index' is composed of the factors temperature, humidity, precipitation, fuel moisture and wind speed (Van Gulik, 2008).

will increase (Van Gulik, 2008). This means that the risk that wildfires pose on the Veluwe is very high in at least one month per year, cumulatively. This risk level makes the Veluwe a suitable case for this research.

Box 2: COROP Veluwe

The abbreviation COROP means Coördinatiecommissie Regionaal Onderzoeksprogramma, literally translated to the Coordination Commission Regional Research Programme. This was created for administrational purposes for the CBS (Statistics Netherlands) and is analogous to the NUTS-3 administrational level of the European Union. The Netherlands is divided into 40 COROP regions.

The COROP Veluwe consists of the municipalities Barneveld, Ede, Elburg, Epe, Ermelo, Harderwijk, Hattem, Heerde, Nijkerk, Nunspeet, Oldebroek, Putten, Scherpenzeel, Voorst en Wageningen. The total count of inhabitants is 667.853 (CBS, 2017).

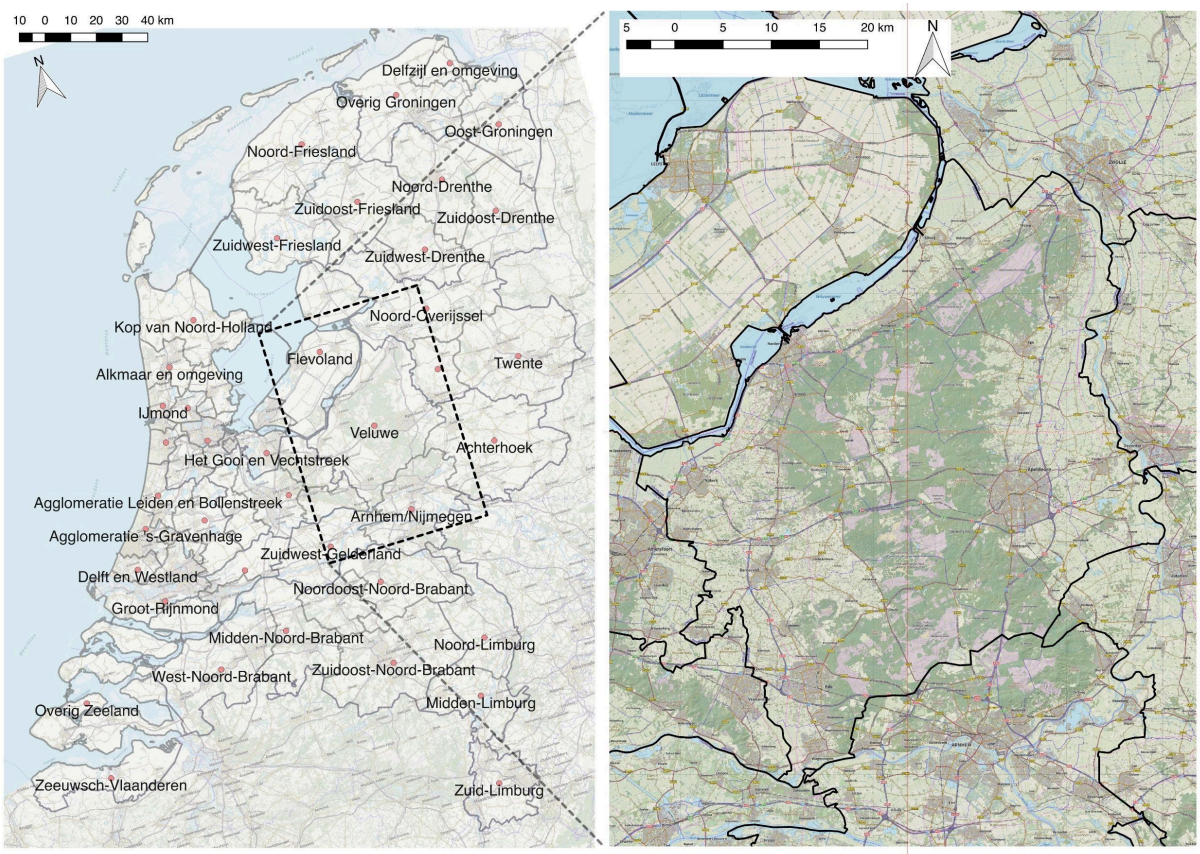

Figure 7: The region COROP Veluwe situated in the Netherlands.

4.2 Wildfire prevention and fuel management options

The outbreak and advance of (wild)fires depends on three essential components, the so-called fire triangle: fuel, oxygen and ignition (temperature). If there is enough fuel and oxygen available, and an ignition occurs, a fire can be sustained (Van Gulik, 2008).

Oxygen cannot be taken away from the atmosphere[1], so wildfire policy has to focus on the fuel and ignition parts. By trying to influence the behavior of visitors to nature areas it is hoped that the chance of ignitions is decreasing.

Limiting the fuel part of the triangle is the concern of the fuel management, reducing the amount of litter, grasses and herbaceous fuel, which is the fuel that sustains spontaneous large, uncontrollable wildfires (Russel-Smith and Thornton, 2013; Calkin et al., 2014). Especially in Wildland-Urban Interfaces, this is an important factor from a safety perspective. Possibilities for fuel management include a broad range of instruments: thinning, mechanical clearing, underburning of fuel and prescribed burning. Thinning and mechanical clearing are already practiced in Dutch forest management, and thus also applicable as fuel management instruments. Taking into account that the risk of wildfires is still increasing however, additional or improved fuel management might be needed, so underburning and prescribed burning are also studied by the Dutch fire department as complementary instruments.

While prescribed burning is part of the wildfire prevention policy in countries such as Canada (Labossière & McGee, 2017), the USA (Quinn-Davidson and Varner, 2012; Harris & Taylor, 2017), Portugal (Fernandes et al., 2013), Germany, Denmark, the United Kingdom (Brennan, 2016) and Australia (Altangerel and Kull, 2013), it is a very limited practice in the Netherlands. Regular large-scale prescribed burning in the Netherlands is currently only occurring at military shooting ranges, because mowing or sod cutting could be dangerous in those terrains due to the possible presence of unexploded ammunition (Brennan, 2016; Infopunt Veiligheid, 2012).

Apart from safety, ecological benefits, the costs of the effort and long-term biodiversity goals should also be taken in to account in the decision if prescribed burning is feasible (Hmielowski et al., 2016). There is much debate on the long-term effectiveness of prescribed burning from an ecological viewpoint, and whether or not it really ameliorates wildfire regimes (Altangerel and Kull, 2013). Positive and negative effects of prescribed burning as a prevention instrument have been described in studies from countries where it is practiced as a forest management tool. In California prescribed fire was effective as a fuel removal strategy in forests long subject to fire exclusion. This resulted in a much lower fire severity when there was a natural wildfire, resulting in less damage (Harris & Taylor, 2017). In a climate model, application of prescribed burning in the Central EU and Baltic countries resulted in a 70% lower increase of burned area by the year 2090. That means that there would be a 60% increase of the burned area[2], instead of more than 200% increase annually burned area in the scenario of 'doing nothing' (Khabarov et al., 2016). However, applied to Tasmania, it was modeled that prescribed burning has only a minimal effect on wildfire risk when used on

[1] For more wildfire mechanics, see Appendix A.4.

[2] Area is compared to the average of annually burned area in the years 2000-2008. Due to the limitations of the model used by Khabarov et al. the effects of the adaptation measures of land fragmentation and species transformation are not calculated.

reasonable scale, and that is should be combined with extensive local-scale landscape design to optimize it (Furlaud et al., 2017). These studies show rather mixed results even when applied on large scales and in ecosystems where fire has ecologically important roles.

Prescribed burning seems to be working best for wildfire risk management in areas with mixed nature types and a moderate climate (Fernandes and Botelho, 2003). In *Pinus* stands with moderate or low tree densities in the USA, prescribed burning was seen to be more effective than mechanical clearing (Pollet and Omi, 2002). A study in *Pinus* growth after prescribed burning in Europe showed similar results. Higher and older *Pinus* trees had better after-fire growth characteristics than younger or lower trees, effectively showing a natural thinning technique by filtering out smaller trees (Valor et al., 2015). So only when a good balance is found between fire intensity, burning interval and damage inflicted on the remaining trees, prescribed burning can be used as wildfire prevention instrument. Above all it could in this way also function as an economically viable forest management tool (Valor et al., 2015). Prescribed burning seems thus to be most usable as instruments for ecological or management goals, not for wildfire mitigation.

Successful application of prescribed fire depends thus on many location-specific factors, and a study that is applicable to Dutch nature is not yet done (Brennan, 2016). In a relatively densely populated area such as the Netherlands many more constraints would apply due to safety, besides the required funding and expertise for training personnel to plan such burns (Pollet and Omi, 2002; Fernandes et al., 2013). Since there is already some expertise and experience about prescribed burning present in the Netherlands, that can be used as building blocks for research into the use of prescribed burning in the Netherlands.

CHAPTER 5

Results

Eight interviews of on average 6210 words (median 60 minutes), were held, and coded with 599 instances of 38 different initial codes. In the selective coding round, these codes were connected to the research questions (see table 6). These sets were used for the further analysis of the indicators.

Theoretical framework / *Research question*	**Risk society** **RQ1**	**Learning capacity** **RQ2**	**Policy cycle** **RQ3**
Matching initial codes	impact on society	barriers between nature and safety	adaptation in management
	klimaat	collaboration	controlled burning
	natuurlijkheid	double loop learning (discuss assumptions)	firefighting adaptation
	risk prioritisation	experience	forest compartimentalisation
	risk society	expertise	fuel management
	risk-index	institutional memory (routine, monitoring &	policy implementation
	societal risk perception	integration nature and safety	prescribed burning
	voorkomen natuurbrand	learning capacity	protocol natuurbrand
	wildfire risk	single loop learning (improvement)	
		stakeholders	
		trust	

Table 6: Selective coding: linking the initial codes to the research question and theoretical frameworks.

Scoring of the indicators resulted in a table with arrows indicating the scale to which the interviewed stakeholders responded to the indicators (see Table 7).

Criterium	Indicator	Safety sector		Terrain managers			(Local) government		
		VNOG	IFV	Kroondomeinen	Staatsbosbeheer	NP De Hoge Veluwe	Rijksvastgoedbedrijf	Ermelo	Harderwijk
Risk society									
Risk prioritization	1	↑	↑	↑	↑	↑	↑	↑	↑
	2	↑	↑	↓	↑	↓	↑	↑	↑
Expertise development	3	↑	↑	→	↗	↗	↗	↗	↗
	4	→	↑	→	↑	↑	↑	→	→
	5	↗	→	→	↗	→	↗	↑	↗
Risk mitigation as cultural qualifier	6	↑	↑	↑	↑	↑	↑	↑	↑
	7	→	→	↓	→	→	↑	→	↘
Wildfire is seen as uncontrollable risk	8	↘	→	↑	↗	↑	→	→	→
Learning capacity									
Trust	9	↑	↗	↑	↑	↓	↑	↗	↑
	10	↗	→	↗	↑	→	→	↗	↓
Single loop learning	11	↑	↗	→	↑	↑	↗	↗	↑
Double loop learning	12	↗	→	→	↗	↗	→	→	↑
Discuss doubts	13	↗	→	→	→	↘	→	↘	→
Institutional memory	14	↗	↗	→	→	→	→	↗	↗
Policy cycle									
Agenda-Setting	15	↑	↑	↑	↑	↑	↑	↑	↑
Stakeholder consultation	16	↑	↑	→	→	↓	→	↑	→
Policy formulation	17	→	→	→	↑	→	→	→	↑
Decision making	18	↑	↑	→	→	↗	→	→	→
Implementation	19	↑	↑	↑	↑	↗	↑	↑	↑
Evaluation	20	→	↗	→	↑	↗	→	→	→
Termination	21	→	↗	→	→	→	→	→	→

Table 7: Measured conformance to indicators of stakeholders. Green arrows: high conformance to indicator, red arrows: results opposite to indicator.

A general overview of Table 7 shows that there are far more arrows up (57%) than down (5%), a sign that most indicators were found in the stakeholders. Still, a considerable amount (38%) got mixed or no indication in the interviews.

The results are also averaged over stakeholder groups and criteria, resulting in a simpler table (see Table 8).

	Safety sector	Terrain managers	(Local) government
Risk society			
Risk prioritization	↑	↗	↑
Expertise development	↑	↗	↗
Risk mitigation as cultural qualifier	↗	↗	↑
Wildfire is seen as uncontrollable risk	↘	↑	→
Learning capacity			
Trust	↗	↗	↗
Single loop learning	↑	↑	↑
Double loop learning	↗	↗	↗
Discuss doubts	↗	↘	↘
Institutional memory	↗	→	↗
Policy cycle			
Agenda-Setting	↑	↑	↑
Stakeholder consultation	↑	↘	↗
Policy formulation	→	↗	↗
Decision making	↑	→	→
Implementation	↑	↑	↑
Evaluation	↗	↗	→
Termination	↗	→	→

Table 8: The results grouped by stakeholder groups and criterion.

In the following sections the results of each indicator are given some context.

5.1 Risk beliefs

#1 RISK WEIGHING Economic gain, so the risk of economic loss, sometimes prevailed over wildfire risk , but public utilities stay unequivocally protected against the wildfire risk (Ermelo). "When we would clear all cut branches from the forest each year, it would cost too much. We won't do that, and we accept the risk it creates." (Kroondomein Het Loo) The NP De Hoge Veluwe noticed that active management resulted in sufficient wildfire risk mitigation. Therefore they rather emphasized this active management than wildfire risk management in the park (NP De Hoge Veluwe). In areas of the Rijksvastgoedbedrijf it's not a difficult choice either: it is a win-win scenario: prescribed burning does not cost much, and has benefits for nature too. At the shooting ranges, there is always a choice made between suppressing and controlled burning of an actual wildfire. This involves a weighing between economical, ecological and practical values (Rijksvastgoedbedrijf).

The wildfire risk is growing in importance inside the safety sector, but according to them it should always be seen in the context of the complete risk spectrum, for example the risks heavy industries pose. The Risk Index (RIN) is a helpful tool for risk prioritization, because it shows where wildfire risk is exceptionally high (VNOG). For example: in some areas where people are isolated in forests, wildfire is really one of the biggest risk occurring (Staatsbosbeheer).

#2 WILDFIRE RISK PREVALENT In six of eight interviews, this seemed to be the case, but it is related to the tasks of the stakeholders. The governmental bodies prioritize safety above values of nature and production. This shows, for example, in that the Gebiedsgerichte Aanpak and compartmentalization measures are followed in their areas (Harderwijk, IFV, Ermelo, VNOG). The Rijksvastgoedbedrijf manages their terrains not primarily for the natural values, but for the purpose of military training, so they put safety first too (Rijksvastgoedbedrijf).

The other terrain managers tend to put nature above safety, and do not follow the suggested wildfire mitigation measures to the end, showing that the wildfire risk is then not prevailing enough to affect nature management. This results for example in a decreased accessibility of areas in general (IFV, Staatsbosbeheer), incomplete implementation of the Gebiedsgerichte Aanpak, when this would damage the productivity or natural functions of the forest. An example of this is the attitude of the two sectors to branch- and topwood, generally left-overs from forest cuttings. Terrain managers want to leave that in the forest since it leaves the nutrients in the system, it provides numerous ecological functions, and is relatively expensive to remove. The fire brigade however sees it as fuel posing a wildfire risk and wants it removed. "One of the problems always concerned the branch- and topwood: the fire brigade always complains about the branch- and topwood: it always has to be cleaned up because it gives so

much combustible fuel, it is so dangerous, all kinds of problems, but in nature conservation it of course is 'dead wood', which is simply valuable for the ecological development of your terrain and for everything that is there, biodiversity." (Staatsbosbeheer) However, in the vicinity of houses or roads, safety becomes the first priority again, and all necessary measures are taken to reduce the risk (Staatsbosbeheer, Kroondomein Het Loo, Harderwijk). The NP De Hoge Veluwe provides a different way of looking at this: when wildfire risk perception is lower, then risk and nature management will be less conflicting. In their view and experience, active nature management is functioning as wildfire mitigation as well (NP De Hoge Veluwe).

#3 KNOWLEDGE DEVELOPMENT Seven fields of knowledge could be distinguished that are being developed (see Box 3). The new policies that are being developed are also designed to be collaborative, so the expertise that is developed in that process is shared. The best example of this is about how the collaborative wildfire fighting is developed: as a new element compared to the 'old' firefighting, the knowledge of the terrain manager should be integrated (Harderwijk, VNOG). Additionally, there is also a national advisor of wildfires who shares knowledge where and when it is needed (IFV).

With regard to written expertise, articles and documents are written that collect or distribute the expertise between nature managers and/or the safety sector (LVN, 2014). One example of this was an article written by multiple of the interviewees (Ermelo, VNOG, Harderwijk and Natuurmonument) in Vakblad Natuur Bos en Landschap about the status quo in wildfire management (Zwart et al., 2016). And lastly, the IFV have standard reporting duty evaluating wildfire events. These are also getting read better than before, indicating a rise of interest and knowledge develop in this regard (IFV).

Box 3: Knowledge development

Seven topics of knowledge were found being developed or expanded:

1. The flammability of dead wood (Harderwijk).
2. The usefulness and validity of the risk barometer is being studied (IFV).
3. There are internships taken in the USA to get more expertise about wildfires (IFV), and there are partnerships with the UK, Germany, Denmark and Sweden to gain knowledge about prescribed burning (VNOG).
4. Preventive sod cutting, mowing and prescribed burning are being developed as more effective wildfire management techniques (NP De Hoge Veluwe).

5. Prescribed and controlled burning are being researched by the fire department (VNOG, Staatsbosbeheer).
6. Knowledge about the ecological benefits of wildfire is studied by ecologists of the Rijksvastgoedbedrijf, in collaboration with Wageningen Environmental Sciences (Rijksvastgoedbedrijf).
7. The Natuurbrandverspreidingsmodel has been finished in 2016 and is now being piloted (VNOG).

#4 KNOWLEDGE EXCHANGE Four of the eight interviewed stakeholders mentioned meetings between stakeholders for knowledge exchange. There are meetings for expertise sharing and development (IFV, Rijksvastgoedbedrijf), but also evaluative meetings after larger wildfires, such as was the case after the wildfire of Kootwijk (2012). On these meetings the safety sector and affected terrain managers are convened (Staatsbosbeheer). And lastly, the VBC convenes annually in which developments concerning wildfire risk are discussed between stakeholders (NP De Hoge Veluwe).

#5 EXPERTISE AS RISK COMMUNICATION FACILITATOR In the Gebiedsgerichte Aanpak, expertise is used to prioritize the risk mitigation measures (Harderwijk, IFV, Ermelo, NP De Hoge Veluwe, VNOG, Staatsbosbeheer) and in prioritizing controlled wildfires (Rijksvastgoedbedrijf).

With regard to risk communication, an article was written by four different stakeholders, in which expertise was used to communicate about the wildfire risk mitigation in natural areas (Zwart et al., 2016). One of the authors, Constantijn Kok of the VNOG, was also repeatedly mentioned in the interviews as an important figure in the wildfire expertise communication.[1] He has a forestry background, bringing the two different views of nature management and the safety sector closer together (Staatsbosbeheer, Ermelo, Harderwijk, Rijksvastgoedbedrijf, Kroondomein Het Loo).

#6 WILDFIRE POLICY DEVELOPMENT In all areas of the interviewed organizations, measures of some kind were taken to mitigate or control the risks of an uncontrollable wildfire, even though there has not been an uncontrollable wildfire since 1976.[2]

#7 RISK MITIGATION COMMUNICATION This was only the case in some terrains. The terrains of the Rijksvastgoedbedrijf are relatively widely known to

[1] No interview has been done with Constantijn Kok.
[2] In 1976 there was a wildfire on the Rozendaalse Veld, near Arnhem. It destroyed 200 hectares, and it was extremely stressful.

be managed in a wildfire risk mitigating way, through prescribed burning. This is especially known with nature managers, the safety sector and academic world (Rijksvastgoedbedrijf).

Nature managers deliberately do not communicate to the general public about the mitigation measures taken in their terrain, because it could lead to contrary ideas with some people (Kroondomein Het Loo, Harderwijk). It is always a tricky balance between informing people too little or too much (VNOG), which is why this is also included in the area-specific approach: in risk-areas there is area-specific risk communication protocol (Ermelo; VGGM, 2015b). Of the other terrains, it is not known if there is structural external communication about how the wildfire risk is mitigated (Harderwijk, Ermelo, IFV, NP De Hoge Veluwe, VNOG, Staatsbosbeheer).

#8 RISK PERCEPTION The results for this indicator showed some interesting differences considering wildfire risk perception. In dangerous periods the general public is very afraid of it: if you look at the media, wildfires quickly create hypes in high-risk seasons (Kroondomein Het Loo, NP De Hoge Veluwe). Even leaving logging remnants in the forest is seen by the public as dangerous (Kroondomein Het Loo), just like prescribed burning would probably be seen as dangerous when it would be proposed as management technique (IFV). Outside of the dangerous periods, when is not hyped anymore, the general public is not really occupied with wildfires and underestimate its risk (VNOG). Interestingly, people in risk areas also are not as afraid or aware of the risk as they should be (IFV). "I think it's not really an issue with the people of the Veluwe. But on specific times and in specific places you would like that it would be somewhat more of an issue with those people, for example in the middle of a nature area with campings with only one or two evacuation roads." (IFV)

"A few years ago, it was something hardly receiving attention, because: what could possibly burn in the Netherlands?" (VNOG)

The nature management sector however, is less worried about the risk of wildfires. They think that local governments are too occupied with 'safety' (Staatsbosbeheer) and that official risk assessments overestimate the wildfire risk (NP De Hoge Veluwe). All interviewed stakeholders thought that the mitigation measures that are taken were sufficient for managing the risk of an uncontrollable wildfire.

5.2 Learning capacity

#9 COLLABORATION With regard to the cold phase, in which wildfire prevention takes place, the context of the Gebiedsgerichte Aanpak (Harderwijk, Ermelo, Staatsbosbeheer, Kroondomein Het Loo) and the area compartmentalization (Ermelo) are collaborative efforts between stakeholders. This includes the safety sector, terrain

managers and municipalities. Other collaboration in this phase includes the exchange of information by the MoD for sharing the expertise of prescribed burning to other terrain managers (Staatsbosbeheer, Rijksvastgoedbedrijf). There is also collaboration with the MoD as users of the military training area for better evacuation of the area (Harderwijk). The IFV has mainly collaboration with fire departments and safety regions (IFV, VNOG), but also with terrain managers for streamlining the collaboration during wildfire fighting. With regard to research, there is also a collaboration with Wageningen Environmental Sciences (Rijksvastgoedbedrijf) and with other countries (UK, Denmark, Germany and Norway) that have more expertise in wildfire fighting (VNOG).

With regard to the warm phase, actual wildfire fighting, collaboration between the safety sector and terrain mangers is essential. The terrain managers are responsible for the initial firefighting when possible, until the fire department arrives on the scene. They also receive and guide the first fire brigades arriving, and can subsequently assist with various activities and advice the firefighting command (VNOG, Staatsbosbeheer, Kroondomein Het Loo).

In the NP De Hoge Veluwe collaboration and information exchange with the safety sector is decreasing, due to disappointments on their side: in the VBC they perceived an imbalance between the red and green sectors, and in their experiences with wildfires in the park the behavior of the fire department was disappointing to them (NP De Hoge Veluwe). This has stifled collaboration quite a bit, although the formal plans for collaboration are still in place.

#10 TRUST From the interviews, 1.5x more mentions were made of trust than of distrust (see Figure 8). Inside organizations there tends to be trust and loyalty (NP De Hoge Veluwe, Rijksvastgoedbedrijf), but inside the fire department there is distrust between high (fire department) and low (fire brigades) levels in the hierarchy of the organization. This is also the case with the two municipalities (Ermelo, Harderwijk), where there is distrust with the other branches of the municipal organization.

Harderwijk, NP De Hoge Veluwe and the Rijksvastgoedbedrijf showed (some) distrust toward the fire department or brigade. For example: ”You cannot criticize the effort the fire brigade put into their work, voluntarily. But we want to have them do the right things.” (Harderwijk) and“the fire department is […] split up very much. I once counted 14 committees that had something to say about wildfires.” (Rijksvastgoedbedrijf) Reasons for this distrust were inability of ‘red’ to understand the ‘green’ values, because of failures in wildfire fighting, because ‘red’ requires too many adaptations of nature management and because the institution of the fire department has so many committees (Harderwijk, NP De Hoge Veluwe, Rijksvastgoedbedrijf).

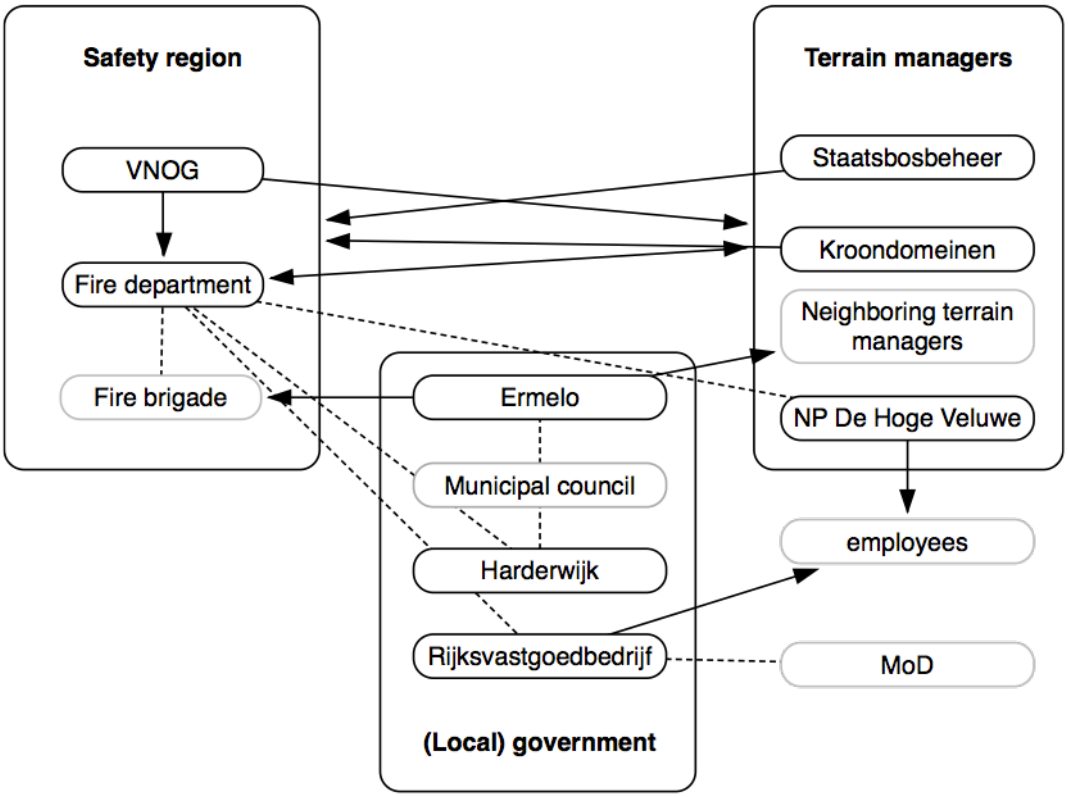

Figure 8: Indicated trust between stakeholders. Arrows signify trust, dotted lines signify distrust. Light grey boxes are stakeholders outside of the research.

#11 SINGLE LOOP LEARNING After the big 1970 wildfire,[1] many fire prevention measures were made or improved in the nature management sector (Rijksvastgoedbedrijf). A few decades later, after two seasons with many wildfires (2010 and 2011), the safety sector had to improve and make specific wildfire fighting regime, and started that process (Harderwijk). Since that time, single loop learning increases: actual wildfires or small-scale prescribed burnings provide experience (Ermelo, VNOG, Staatsbosbeheer), the wildfire evaluation reports get better read (IFV), and large wildfires end with an evaluative meeting, such as the face-to-face evaluation with all stakeholders involved in the 2012 Kootwijk fire (Staatsbosbeheer). Through the Gebiedsgerichte Aanpak and exercises the evacuation phase is very much improved, and is now much more extensive than before (Harderwijk). In NP De Hoge Veluwe wildfires provided the opportunity to learn that active nature management (sod cutting, mowing and prescribed burning) might be the best wildfire mitigator, and to improve communications during a wildfire (NP De Hoge Veluwe).

[1] In 1970, 300 hectares were burned in 't Harde, probably caused by a military shooting exercise (Harderwijk, Rijksvastgoedbedrijf).

#12 DOUBLE LOOP LEARNING Indications of double loop learning were encountered in four interviews. In general it was mentioned that sometimes reality is different from expected (Harderwijk, VNOG, Staatsbosbeheer). VNOG called it an illusion to expect that everything you prescribe and is documented, always turns out as such (VNOG). This applies to wildfires, and their effects on nature (Harderwijk). For example, when fire breaks are used as wildfire risk mitigation, it will turn out that they are not so useful in case of heavy wildfires, because an intense fire can jump over 150 meters in the right conditions (Staatsbosbeheer). It also applies to false suppositions. According to the NP De Hoge Veluwe, the fire department does not look closer into forest systems than their own established opinion about it. Various measures that they prescribe might have different (second order) effects than they expect. One example of this is that the opening up of a forest stand by removing the bordering shrub layer, intended to remove a fuel ladder, also changes the microclimate of the stand, making it dryer and thus a bigger wildfire risk (NP De Hoge Veluwe).

#13 DISCUSS DOUBTS Doubt wasn't showed often in the interviews. In case of Ermelo it was clearly not present inside the municipal organization, because of a lack of trust. It was described as a lack of understanding of the uniquely differing roles of a municipality: a municipality has largely a governing and civil task, but also partly a private law role in managing the area beloning to the municipality. "We have of course political leaders: the municipal council and the executive council, but on the other side there is the whole administrative organization which keeps the complete municipality running. Problem is that inside the administrative organization there is a private law part: the management of the nature areas of the municipality. Even our executive council is not aware of the difference between the private management of those nature areas and the administrative management and of the rest of the municipality." (Ermelo) Because of these clashes between interests, trust is low with the terrain managers inside this municipal institution, which stifles the vulnerability to discuss doubts (Ermelo). This same struggle also showed in the interview with Harderwijk.

With the NP De Hoge Veluwe and other terrain managers there was only trust in their own practice noticeable, and there seemed to be little room for discussing doubts. "We think that we can fight a wildfire better than the fire department; in the next case we will just go and send some flail mowers to create fire breaks upon which the heath fire is going to break. I think that will be much more effective than calling the fire department, because they don't listen and are stubborn." (NP De Hoge Veluwe).

The only place where this doubt was encountered was in the VNOG. There was some open doubt about the responsibility sharing in the cold phase of wildfires, what their and other's responsibilities are. Other examples of these doubts in the VNOG concerned their operational capacity: while they should be able to control a wildfire in their region, when it gets quite big they still need to ask help from other safety regions. Also they need knowledge they don't have, about the way that foresters used to apply

prescribed burning before the fire department took that responsibility in 1985. These questions drive discussion with other institutions, and could lead to an effective and adaptive collaboration between them.

#14 INSTITUTIONAL MEMORY In the current research some form of institutional memory was only found in the public organizations (IFV, VNOG, Ermelo and Harderwijk). These organizations mentioned routines, evaluations and documentation as characteristics of institutional memory.

5.3 Policy development

#15 AGENDA SETTING Agenda-setting was encountered with all interviewed stakeholders. With some it had already been quite longer on the agenda (Harderwijk, VNOG). For the others, it was on their agenda because the wildfire risk poses a safety issue, or just because the safety region had put in on their agenda (Kroondomein Het Loo). It was the safety region's responsibility of initiating a collaborative wildfire mitigation policy in nature areas where the RIN shows high risk areas, and that is being done (Winkelman et al., 2014).

#16 STAKEHOLDER CONSULTATION Only the municipality Ermelo and the safety sector stakeholders mentioned the stage of stakeholder consultation clearly. In Ermelo management changes are consulted with the involved stakeholders, whether they be camping owners or residents (Ermelo). The VNOG always has to consult stakeholders about policy that concern certain parts of their region. This is also true for the IFV, for example: they have to work together with campings in high risk zones to make them safer, which involves not only consultation but also collaboration (IFV).

The NP De Hoge Veluwe however, mentioned the opposite of stakeholder consultation: it generally does not really want to listen to the public, because they trust their own judgment better. "We do not think about the visitors at all, we have put that beside us. We just go our own way and if we receive positive reviews, then we are receptive to that. But if someone starts calling all kinds of things that we have to do, then we say: 'That's fine that you think so, but we do not do anything with it.'" (NP De Hoge Veluwe)

#17 POLICY FORMULATION Objectives for wildfire risk mitigation policies were almost never concretely mentioned. Only Harderwijk mentioned that the compartmentalization and Gebiedsgerichte Aanpak policies were clearly and concretely described (Harderwijk), and Staatsbosbeheer mentioned that the 'safety of people in

the area' was an objective for these management adaptations (Staatsbosbeheer). Winkelman et al. (2014), a document of terrain managers, describe the objective of collaborative wildfire fighting as "minimizing the chance for wildfire escalation toward uncontrollability".

#18 DECISION-MAKING With regard to the decision making stage, alternative management options are not really in scope. The different programs that are in scope (the Gebiedsgerichte Aanpak, the compartmentalization and the collaborative firefighting) are not alternatives of each other, but rather complementary instead of exclusive, and may be implemented separately.

The IFV and VNOG made mention of different wildfire fighting methods, which are compared on impact, and deployed per wildfire instance (IFV, VNOG). In the NP De Hoge Veluwe there was no fair comparison between two alternatives: the two different approaches for wildfire fighting of the park and the fire department. Rather it was a choice based upon disappointing collaboration with the fire department (NP De Hoge Veluwe).

#19 IMPLEMENTATION The policies that are chosen to be implemented in some form are the Gebiedsgerichte Aanpak, nature compartmentalization, prescribed burnings, wildfire fighting collaboration and communication protocols. The Gebiedsgerichte Aanpak is implemented in Harderwijk and the Kroondomein Het Loo, and in the process of being implemented in Ermelo. In the NP De Hoge Veluwe the Gebiedsgerichte Aanpak will not be completely implemented, they have made some adaptations themselves (NP De Hoge Veluwe). Staatsbosbeheer is also not really amused about the Gebiedsgerichte Aanpak, because it is written too much from a 'red' perspective. "The current protocols (the Gebiedsgerichte Aanpak) are written from the fire department viewpoint, and requires a lot of adaptation from the nature managers. We think that should be done in collaboration." (Staatsbosbeheer)

Infrastructural adaptation and compartmentalization are being implemented in the areas of Staatsbosbeheer and Ermelo, sometimes by direct transformation and sometimes through thinning and natural regeneration, which takes time. Prescribed burnings are happening in areas of the NP De Hoge Veluwe and Staatsbosbeheer, but in NP De Hoge Veluwe not completely according to the code that has been formulated by the VBNE (NP De Hoge Veluwe).

Some municipalities are making policy about collaboration in case of wildfires and about wildfire risk mitigation, and implementing these policies (VNOG). This collaboration in case of wildfires is implemented well in the areas of Staatsbosbeheer and the Rijksvastgoedbedrijf, but are disappointing in other areas (Ermelo, Harderwijk). Shared communication protocols are also part of the new wildfire approach, although

sometimes the messages from fire departments are still different from terrain managers (Ermelo, IFV).

#20 EVALUATION Not many organizations mentioned a regular evaluation of the policy, its implementation or effects. The NP De Hoge Veluwe mentioned the evaluation of wildfires internally, in their own organization, but not with the fire department (NP De Hoge Veluwe). This did happen with Staatsbosbeheer on the other hand, where an evaluation meeting was held in 2012 about the wildfire in Kootwijk, concluding that the collaborative wildfire fighting went quite well. "Over the years the collaboration has gotten better, and with the latest wildfire it went quite well as intended." (Staatsbosbeheer).

The IFV has the responsibility of reporting on wildfires, and mentioned that these reports got more often read than before. Concerning the Gebiedsgerichte Aanpak they evaluated that it seems to have the desired effects, although up until now it has not gotten the ultimate test yet: an actual wildfire (IFV).

#21 POLICY TERMINATION Because the field of wildfire management is still in development in the Netherlands, not many programs are yet terminated. The only mention was that the risk barometer is almost being terminated, because upon close inspection it resulted in more confusion with the general public, and has a second order effect that made wildfires in lower-risk days a higher risk, because the safety sectors call out less troops on those days initially (IFV). In the spring of 2018, this policy was indeed terminated, and a binary classification is now in use: phase 1 for no special risk, and phase 2 when there is some alertness required.[1]

[1] See https://www.natuurbrandrisico.nl/over-deze-site.html and https://www.gelderlander.nl/de-vallei/brandweer-schrapt-kleurcodes-bosbrand-code-rood-schrikt-te-veel-af~a150e4fb/.

CHAPTER 6

Discussion

The goal of this research was to examine the intersection between nature management and wildfire risk mitigation. This examination was especially focused on the perception of the risk, the collaboration between stakeholders and the production of wildfire risk policy. In the following sections, first the results will be reviewed, then the methods will be discussed and it will end with a reconsideration of the theoretical framework.

6.1 Discussion of results

The results will be discussed firstly for each criterium, and then for each theme and sub research question.

6.1.1 Risk beliefs

RISK PRIORITIZATION A risk society is predominantly occupied with risk management. This would show in that decision making is influenced by various risks that get weighed. Another characteristic of the risk society in nature management would be that the wildfire risk prevails in decision making over other functions of nature, such as productivity or nature functions.

The results show that all stakeholders do some weighing of some risks in their practice or policy making. Six of the eight stakeholders seemed to scale the risk of wildfire higher than other risks and this could be related to their respective tasks. The governmental bodies (municipalities, safety sector and Rijksvastgoedbedrijf) have to ensure the public safety, and will ultimately prioritize safety therefore above values of nature and production. The other terrain managers more often put nature above safety, and don't follow the suggested measures to the end if they interfere too much with the other values and functions of their terrains, showing that the wildfire risk is then not prevailing enough to affect nature management.

EXPERTISE DEVELOPMENT A second criterion of the risk society is expertise development. This can be done with research, but also important is knowledge

exchange between stakeholders through conferences or other wildfire-related meetings. This expertise will finally be used as a foundation for risk communication and prioritization.

In this case, expertise is being developed (see Box 2). There are also conferences and meetings for knowledge exchange, but not in overflowing measure. The current amount of meetings does provide a network for knowledge exchange between stakeholders, but a region-wide regular conference for monitoring the wildfire policy might still be a recommendation. For a good valuation of this criterion of the risk society however, it should be seen in comparison to knowledge development concerning other risks, which is not in the scope of this study. Here, it can only be concluded that knowledge is being developed and shared, and that the wildfire risk is in that regard a field of interest.

Thirdly, the expertise that was developed was not used much for risk communication, as would be expected in a risk society. It was used for risk prioritization, so there the importance of expertise to a risk society shows.

QUALIFYING RISK MITIGATION In all areas of the interviewed organizations, measures of some kind were taken to mitigate or control the risks of an uncontrollable wildfire, even though there has not been an uncontrollable wildfire since 1976. The third research question deals more extensively with the different kinds of policy that have been implemented. For the risk society thesis it is only important to acknowledge that the wildfire risk is perceived real enough that there are mitigating policies implemented against it.

In a risk society, risk mitigation measures are features about which is externally communicated or upon which areas are identified by the public. This was only the case in some terrains; in most terrains of the interviewed terrain managers it was explicitly not being disclosed to the public. This seeming discrepancy is due to the risk itself: the public itself poses part of the wildfire risk, so it is a risk management decision whether or not to tell the public about wildfire risk mitigation measures, thereby indicating that the wildfire risk is significant.[1]

RISK PERCEPTION The last criterion for the risk society is the risk perception. In a risk society, the risk tends to get easily exaggerated. In this case there are a few interesting differences considering wildfire risk perception. The interviewed stakeholders, being professionals with regard to safety or nature management, had an informed risk perception. The safety sector seemed to have a quite high risk perception, while the terrain managers had a lower risk perception. This might be due to their

[1] This would be an interesting research topic: In a situation where the risk from the public is big, what role does an uninformed vs. an informed public play from the perspective of wildfire mitigation?

professional scope: a terrain manager is largely occupied by a smaller nature area than a safety region. It resembles the tragedy of the commons problem: when safety is not the highest priority, terrain managers would rather profit from the wildfire safety measures taken in neighboring terrains than on their own terrain. Since wildfire risk is a border-crossing problem, safety from that risk is to some extent a commons. The manager of the commons, the safety region, has to allocate safety measures fairly across the users of it. The users of the commons 'safety' will tend to overestimate its amount, while the commons' manager tend to see it more realistically.

The difference in perception might also have to do with the trend they expect for the risk, for example its relation to climate change. Most terrain managers see some impact of climate change in their terrains: dryer and wetter areas and periods, even changing ecosystems because of that. But they do not see a relation of these more extreme weather events to wildfires. The safety sector does expect a growth of the wildfire risk due to climate change. This is however not a necessary causal relation for people to still develop wildfire mitigation measures (Wilson et al., 2017).

Societal risk perception is dependent on the circumstances. In high-risk times there is reason to think of Dutch society as a risk society: the societal feeling is easily influenced by the media, the risks get exaggerated, some stakeholders refer even to it as 'a big hype'. According to Brennan (2016), 73,8% of people on the Veluwe believe a wildfire is (very) likely to occur in the Netherlands. Outside of these high-risk periods however, it is not a big topic in society, and even underestimated.[1]

which were inflated by the use of risk-indicating codes communicated by the safety region.

With regard to the first sub research question about the stakeholders' beliefs about the wildfire risk, this research used the characteristics of the risk society to identify beliefs. Four criteria were used as characteristic of a risk society: the risk is prioritized in the decision processes, expertise is developed and shared, wildfire risk mitigation is a cultural qualifier and there is the perception of wildfires as an uncontrollable risk. All three stakeholder groups show some characteristics of a risk society, but differences occur mainly between the private and public organizations. Private terrain managers show indicators of high risk reception by society, while the safety sector and (local) government did not. It is the other way around with the first criterion: risk prioritization. Here the public stakeholders score very high, while the private stakeholders score lower.

The risk society hypothesis in this case becomes less convincing when looking at the third criterion: even though wildfire mitigation policies are present at all interviewed

[1] A tendency to naiveness might be seen here: that by definition people think that others face more risk than themselves. When 'others' become a large group, such as in high-risk periods, only then the risk perception inflates, and becomes a hype.

organizations, they are mostly not used as cultural qualifier, and only slightly as communication instrument. The wildfire risk mitigation measures have not created a major organizing force in society up to now; the other functions of the nature areas are still largely prevalent over the wildfire risk. The observation that wildfire risk mitigation is not a cultural qualifier is probably partly an interaction with the societal interest for the wildfire risk, which is only high for a limited time each year.

Similar results show with regard to expertise development. As a characteristic for a risk society, the results were partly as expected: the 'expert' organizations, the safety sector, were most occupied with expertise development, and the terrain managers the least. This shows also the institutional weakness of strong one-sided reliance on scientific experts (Termeer et al., 2012). However, this expertise was not used for external communication.

Two explanations for these observations are that either the wildfire risk isn't perceived great enough that the risk society requires further-reaching measures to mitigate it, or Dutch society can't be typified quite like a risk society, but rather as a society that has very well learned to deal with risks, and created institutions to deal with them. This risk controlling, monitoring and containing tendency is also a risk society characteristic (Moore and Reynolds, 2018). With regard to the wildfire risk it looks like the Dutch society might be an evolved risk society in the way that historically the risk management institutions were already in place,[1] and this institutional memory also enables it to create new risk management institutions, for example for the growing wildfire risk.

With regard to the first sub research question about the stakeholders' beliefs about the wildfire risk we see that all of the stakeholders acknowledge the risks and impact of a wildfire on their terrains, due to wildfire experiences and/or the presence of people or public utilities. Although it is, according to most stakeholders, a natural phenomenon, and quite a positive influence on nature, in the Netherlands it should only have limited opportunities, because of the relatively small scale of the region.

However, the perception of the size of the risk differs between stakeholders. In general, the safety sector stakeholders estimate the risk higher than the terrain managers. This might be because they have a responsibility for a larger area than each terrain manager individually. Another reason might be that they have the distinct duty of ensuring the safety, while terrain managers are also occupied with other area functions: productivity, nature or tourism. The current measures of wildfire mitigation are for the larger part not too intrusive upon the other functions of the areas, and can thus be coexisting with their current management.

[1] Historically, the Netherlands have long had to fight environmental risks, of which flooding is by far the oldest, largest and also actual risk.

6.1.2 Learning capacity

TRUST Adaptive capacity starts with trust between institutions, and one of the indicators of this trust in the presence of collaboration between organizations. Lower collaboration and trust can also be caused by uncertainty about the responsibilities of the stakeholders. Collaboration enhances mutual trust, learning and knowledge gathering (Bergsma et al., 2012).

While collaboration can be an indicator of (some measure of) trust, trust can also be inferred from what interviewees stated about each other. Inside the interviewed organizations there tends to be trust and loyalty, but inside the fire department there is distrust between high and low in the hierarchy of the organization. This is also the case with the two municipalities, where there is distrust with the other parts of the municipal organization. Harderwijk, NP De Hoge Veluwe and the Rijksvastgoedbedrijf showed (some) distrust toward the fire department and fire brigade. Reasons for this distrust were value differences, disappointments, too little negotiation and because the institutionalization of the fire department. This leads to thinking that organizations with more multi-level structures (the fire department and municipalities) grow more internal distrust, grown out of misaligned interests and a lack of understanding and interaction.

Overall, there were more expressions of trust than of distrust, but inside large organizations and between policy and management levels, distrust is still a problem, because of misunderstanding and misaligned interests.

SINGLE-LOOP LEARNING This indicator is quite present in all stakeholder groups. In a world where stakeholders are gradually faced with changing circumstances, most stakeholders are able to apply single-loop learning to improve their practice. Since in the studied case the wildfire risk is not yet tightly controlled, stakeholders are still able to incrementally improve and experiment with changing practice (Hurlbert & Gupta, 2017). New techniques are experimented in the NP De Hoge Veluwe, evaluations are getting increased attention for learning opportunities.

DOUBLE-LOOP LEARNING Double loop learning is a kind of institutional introspection: the internal investigation and challenging of the presuppositions that underlie the organization's practice. Signs of this indicator were seen in four interviews (Harderwijk, VNOG, Staatsbosbeheer, NP De Hoge Veluwe). In general it was mentioned that sometimes reality is different from the documented and prescribed expectations (Harderwijk, VNOG, Staatsbosbeheer). It also applies to false suppositions: sometimes, the assumptions have to be reviewed. So, this kind of double loop learning does happen, but not intentionally. Intentional double loop learning can be a point of improvement for all involved stakeholders. For that, it is necessary that stakeholders

consciously decide to reconsider their practice, and what assumptions lay behind this (Lavell et al., 2012).

DISCUSS DOUBTS For an institution to be adaptive, it is also important that it is critical about its own practice or policy. There should be room for uncertainty and criticism in the discussion and communication about an organization. This indicator differs from double loop learning in that it is an inter-institutional trait, not an intra-institutional trait.

This kind of openness wasn't showed often in the interviews. In case of Ermelo it was clearly not present inside the municipal organization, because of clashes between interests. Trust is low with the terrain managers inside this municipal institution, which stifles the vulnerability to discuss doubts, and rather encourages to defend the respective position, which is the opposite of being open about doubts (Ermelo). With the NP De Hoge Veluwe and other terrain managers there was only trust in their own practice noticeable, and there seemed to be little room for discussing doubts. Not only is this an indicator of lower adaptive capacity, it also hinders the external communication about their practice because it is not open to different ideas. In this way it has an isolating effect, contrary to the other collaborative approaches to the wildfire risk.

The only place where this open doubt was encountered was in the VNOG. There were some doubts about the responsibility sharing in the cold phase of wildfires, what theirs and other's responsibilities are. Other examples of these doubts in the VNOG are about their operational capacity. These questions drive discussion with other institutions, from both the safety and nature sector, and could lead to an effective and adaptive collaboration between them.

INSTITUTIONAL MEMORY Institutional memory ensures that the practices of institutions are thoroughly evaluated, documented and stored. This increases adaptive capacity because then practices can more easily be changed or resumed and mistakes can be avoided in that. In the current research some form of institutional memory was only found in the public organizations (IFV, VNOG, Ermelo and Harderwijk). This could be explained by the facts that these organizations are generally older, with lower change-rates and more routines, that they have protocols for evaluation and reporting, and a legal obligation for transparency.

Overall, four of the five criteria for learning capacity were met in all stakeholder groups. Discussing doubts was the only criterion that was negatively rated. Interesting differences can be seen between stakeholder groups (see Table 8). On average the safety sector showed the highest learning capacity, with the (local) government coming second, and terrain managers having the lowest score for learning capacity. This corresponds to the findings of Klostermann et al. (2009) that saw the 'nature' sector as

most conservative and least adaptive. Also striking was the distrust present in organizations with distance between the policy development and implementation levels, a feature of weak adaptive capacity (Termeer et al., 2012). The other weakness in learning capacity described by these authors, a lack of openness towards learning and variety, was partly found: the organizations were quite open to both single- and double-loop learning, but scored poorly on openness about doubts.

Through the results of these indicators an answer for the second sub research question can be formulated: "How are stakeholders collaborating in management with expertise and experience, and what barriers are still there?" The stakeholders are collaborating both in the cold and warm phases of wildfire risk mitigation. In the cold phase there are exercises for wildfire fighting, to practice the procedures that have been agreed upon: about the advising role of the terrain managers, about the less suppressing way of firefighting, the use of controlled burning and the accessibility of the terrain. The Gebiedsgerichte Aanpak is also executed in the cold phase. This is a collaboration between safety region and terrain managers to increase an area's resilience against wildfire by taking mostly small interventions in the terrain: removing fuel ladders and widening or creating fire breaks.

The expertise of the MoD fire brigades of prescribed burnings is only limited available, because of their busy schedule. But still they help and advise sometimes when terrain managers want to exercise or use prescribed burning. Fire brigades also want to participate here, because they can also collect experience and knowledge concerning prescribed burning. In the warm phase, the success of the collaboration depends more on the level of exercise that has been done, and upon the extent of compliance to the agreement to collaborate. Expertise of the terrain manager can help in the CoPI, since it can advise the commander about the accessibility, priority areas and water availability. The implementation of this command depends upon the amount of specific exercise the fire brigade personnel in the field has gotten, and upon the leadership and experience of the CoPI.

There are also barriers to successful collaboration found in this research: each individual's expertise, background and experience can create a barrier of misunderstanding, misinforming and commitment. Expertise can lead to arrogance, backgrounds can contain prejudices and experience can have been built up of disappointing collaboration. There are in general more barriers on the management level than on the executive level, because 'in the field' people already know each other more and have generally a better collaboration because of a partly shared history together. But when this is not present, and in the 'heat' of a wildfire, then 'old' ideas and the non-collaborative fire suppression style often emerge again. On the management level, collaboration between the safety sector and nature management is relatively new, and is going through the difficult exercise of integrating and valuing each other's expertise, experience and views.

6.1.3 Policy development

In the second sub research question, we already described some policies which the stakeholders have created for wildfire risk mitigation. These policies will in this third sub research question be evaluated through the framework of the policy cycle.

AGENDA SETTING The first stage of the policy cycle is confirming that the issue is on the agenda. This was the case with all interviewed stakeholders. So this stage is covered, as expected, since this research also looked for the stakeholders that had the wildfire risk on the agenda.

STAKEHOLDER CONSULTATION Only the municipality Ermelo and the safety sector stakeholders mentioned the stage of stakeholder consultation clearly. The NP De Hoge Veluwe however, mentioned the opposite of stakeholder consultation: it generally does not really want to listen to the public, because they trust their own judgment better. This too might have to do with intersectoral differences. The NP De Hoge Veluwe operates in a different sector, in which market principles also play a role and the public is consulted more by their visits to the park than through their say in the policy (NP De Hoge Veluwe). This policy development stage seemed either not to be important to or not necessary for all organizations in this research, but clearly for some public organizations. Apart from the legal obligation to stakeholder consultation, the studied public organizations were also executioners of the wildfire risk mitigation programs on terrains they did not own, so they had to include the involved stakeholders.

POLICY FORMULATION Effective policy requires clear description of its objectives. Objectives for wildfire risk mitigation policies were almost never concretely mentioned, either because they seemed implicitly clear or were not that clearly described in policy. Only Harderwijk mentioned that the compartmentalization and Gebiedsgerichte Aanpak policies were clearly and concretely described (Harderwijk). Staatsbosbeheer was also very clear about the policy, and that the people's safety was the norm. This corresponds to the finding of Van Engelen (2018) with Staatsbosbeheer's nature managers, which were that damaging private properties was the biggest factor for the acceptability of suppressing wildfires.

Reasons why this indicator, besides these two stakeholders, is largely not present, can be found in the level on which policy development is occurring. Policies such as the Gebiedsgerichte Aanpak have clear descriptions, but management adaptations on a lower level rarely have black-on-white objectives: these consisted more in verbal agreements between stakeholders.

DECISION-MAKING In policy development for phenomena that are as irregular and location-specific as wildfires, there is not a public tender for a policy proposals which can be compared and of which one is chosen. This might partly explain why few alternative policy options are considered. Notwithstanding, wildfire risk mitigation policy development in the Netherlands is still in the starting phase, so a range of policy options is not yet widely available to choose from. Also, many programs are not mutually exclusive and do not require a decision for a single program (Jann & Wegrich, 2007).

IMPLEMENTATION There are quite some polices implemented already. The policies that have been implemented in some form are the Gebiedsgerichte Aanpak, nature compartmentalization, prescribed burnings, wildfire fighting collaboration and communication protocols. Even though these five measures are (being) implemented, it is also clear that the this is not happening perfectly: not everybody agrees with the formulation, and the plans are not executed completely. Here, the deviation from the policy formulation could not only simply be explained by bad implementation, but also by bad policy design: not everyone feels fairly represented in the policy development, and not all values weighed fairly (Jann & Wegrich, 2007). For more agreement, this should therefore be evaluated thoroughly and adjusted.

EVALUATION Policy implementation should be followed up by (regular) evaluation, to monitor effectiveness or to make small adjustments. Not many organizations mentioned a regular evaluation of the policy, its implementation or effects. Wildfires incidents are always reported by the safety region, and larger ones are evaluated, also together with the nature sector. Evaluation showed for example that the collaborative wildfire fighting went quite well in the 2012 Kootwijk wildfire. The preventive measures however, such as the Gebiedsgerichte Aanpak has not been evaluated, because it has not been tested yet in an actual wildfire.

POLICY TERMINATION In a complete policy cycle, it is important to terminate ineffective programs, to prevent a waste of energy in ineffective programs. To measure this, attention was paid to mentions of programs, policies or management that did not have the desired results and were terminated.

Since this field is still in development in the Netherlands, not many programs are yet terminated. The only mention was that the risk barometer is almost being terminated, because upon close inspection it resulted in more confusion with the general public, and has a second order effect that made wildfires in lower-risk days a higher risk.

The seven stages of the policy cycle can indicate how integrated wildfire risk manage-

ment policy is being produced by the stakeholders. Not all stages were equally represented in the interviews. Especially the private terrain managers showed the most deviation of the policy cycle stages, while the safety sector showed the most conformity to the policy cycle model.

According to the policy cycle model, in a fully developed policy cycle a presence of the first six stages could be expected. This is to a certain extent the case in the current research. The seventh stage, policy termination is only once mentioned, due to the relative newness of this field of policy. Especially the policy formulation and evaluation stages scored low in the interviews. This can have its causes on the level of policy or program development, a point also made by Jann & Wegrich (2007) concerning the policy implementation.

Most stages showed differences between the stakeholder groups (see Table 8). The most striking in this regard are the stakeholder consultation and decision making stages. Reasons in this case are first the contrary expressions to visitor consultation of NP De Hoge Veluwe, and secondly the well-expressed presence of the decision-making stage with the safety sector. However, these results might also touch upon deeper differences between stakeholder groups.

The safety sector is in this case the main driver for wildfire risk mitigation policy development, due to their public responsibilities, while the other stakeholders are necessarily partners in this policy development process. Not surprisingly, conformity to the most stages was highest in the safety sector, and lower in the other two groups. The safety sector, driving the policy development also Further research might shed more light on these intersectoral differences concerning the policy cycle. Are these better explained by their different levels of operation or by their execution of the policy cycle? There could be a difference between the public and private domain concerning the policy development cycle, because of operational differences and different norms and constraints.

There are multiple instruments for mitigating the (uncontrollable) wildfire risk that have been taking place (see Figure 9 and Table 9). Most of these policies are quite integrated in the sense that they are made in collaboration of the involved stakeholders, and that they are implemented mostly according to plan. However, not all stages of the policy cycle were recognizable in the policy development process, and there were also differences in learning capacity between the terrain managers and the safety sector. These intersectoral differences might in the future lead to ineffective collaboration, incomplete policy implementation and create barriers for further adaptation.

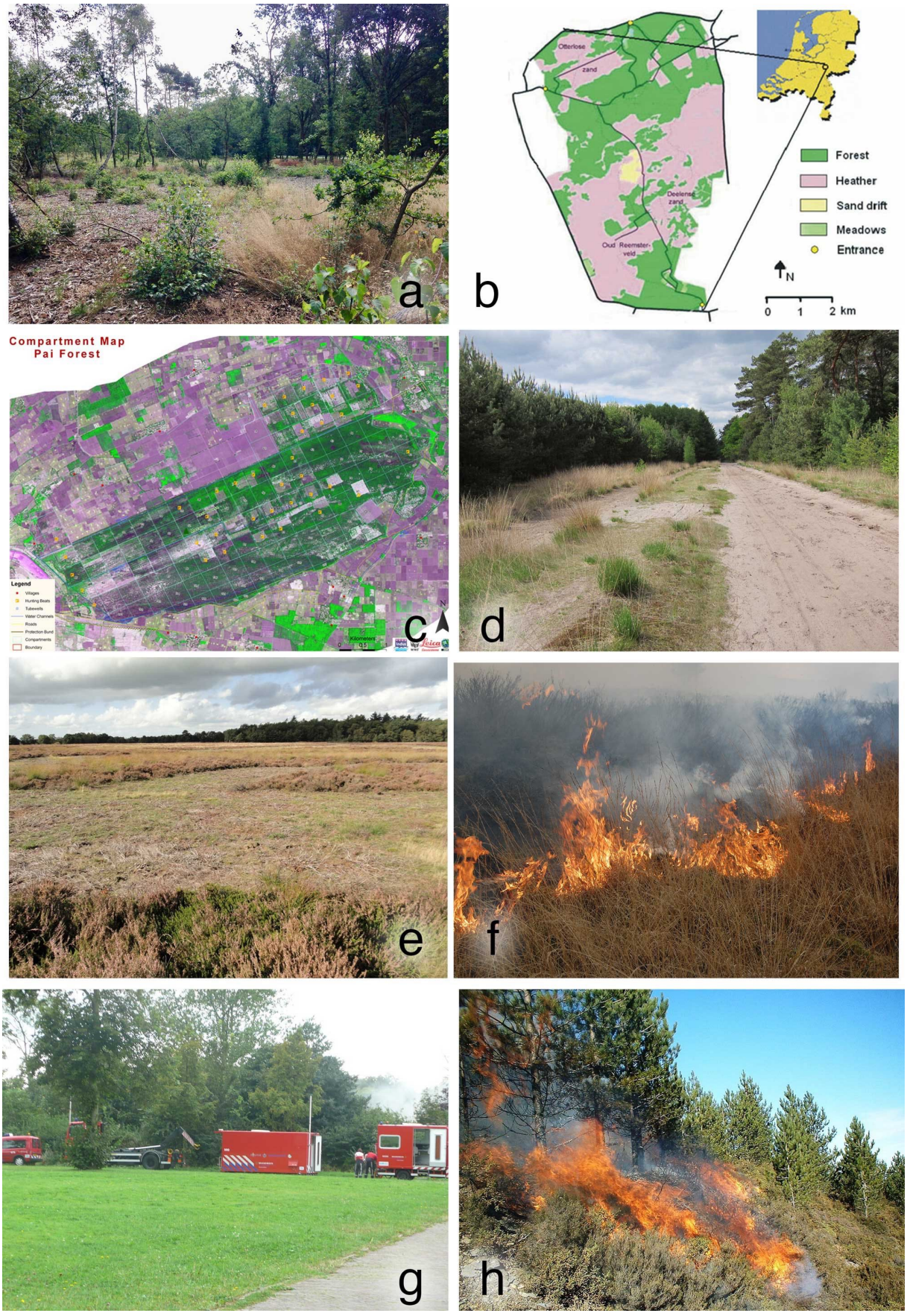

Figure 9: Wildfire risk mitigation measures in the Netherlands. For descriptions, see Table 9.

a	Transforming nature to more fire-resistant species: removing Pine, Douglas and Larch. This is a long-term plan that is being implemented in many places on the Veluwe. The production forests will probably be the slowest in this regard, but there wildfire risks can in the meanwhile be mitigated in other ways.
b	The Gebiedsgerichte Aanpak is a collaborative effort between the safety sector and certain nature managers to improve the resilience of nature areas by making some (often small) changes. It started in 2012 as part of the project Wildfire Management of the fire department, and has by now been implemented in around a dozen areas. With the Natuurbrandverspreidingsmodel, the escalation of a potential wildfire is modeled, upon which critical features of the terrain can be identified. These features, for example a fuel ladder, or one solitary tree connecting two forest plots, can be the focus of adaptation to limit this risk.
c	Related to the Gebiedsgerichte Aanpak is the compartmentalization. This is passive fire protection by separating plots of forest or heath through fire-resistant zones upon which a wildfire breaks. This only works with wildfires with a limited intensity.
d	These fire breaks can also be roads that also provide accessibility. Accessibility is very important for wildfire fighting because the speed with which a fire brigade can find the wildfire co-determines a successful suppression of it. Another important accessibility feature is the water availability, which can be increased by digging wells or ponds.
e	Fuel management is the removal of fuel, one of the requirements for a wildfire. This can be done mechanically, through thinning, cud sodding, mowing or manually. The fire departments would like to have all branch- and topwood removed.
f	Prescribed burning is also a fuel management technique, with the method of removal not being mechanical, but by (under)burning. By controlled burning of fuel an unplanned wildfire will have less fuel to escalate.
g	A collaborative approach to wildfire fighting with the terrain managers is starting, and working more or less. In this method, the terrain managers have a permanent advisory role in the fire department command. This improves navigation in the terrain, knowledge of water availability and accessibility and which parts of the terrain have higher priority than others.
h	Areas of lower priority can be left burning if it doesn't pose extra risk afterwards. This controlled burning can also be used intentionally: to fight fire with fire. Before the front of the wildfire, a zone could be cleared of fuel. If this happens by burning, it is called controlled burning, but it can also be done mechanically, by flail mowers for example.

Table 9: Description of wildfire risk mitigation measures in the Netherlands.

6.1.4 Discrepancies between nature and safety sector

With regard to the fourth sub research question, the policies of nature management and mitigation of wildfire risk from a safety perspective were compared upon their compatibility. Building upon what has been discussed up to now, this section describes the discrepancies that were found between these two sectors.

When nature management characteristics are compared to the eight wildfire risk mitigation measures that are taken (see Table 9), four of them show a discrepancy. The Gebiedsgerichte Aanpak (Table 9-b) is not equally successful in every area (NP De Hoge Veluwe). Staatsbosbeheer feels that the Gebiedsgerichte Aanpak is written too much from a 'red' perspective and that measures are too much enforced without a compromise being looked for (Staatsbosbeheer). This is a discrepancy, since the goal of the Gebiedsgerichte Aanpak clearly was that all parties would be involved fairly,

the risks and benefits would be weighed and deliberated, and a conscious choice taken by all stakeholders.

Compartmentalization (Table 9-c) is only effective when implemented on at least a regional scale, and should therefore also be a regional feat, because it requires the coordination between all terrain managers. However, not all terrain managers are participating equally in this, for example, Rijkswaterstaat is not even managing the roadsides of the regional highways very well, locally creating a high wildfire risk and endangering the highways and neighboring terrains. Rijkswaterstaat is also not participating in the Gebiedsgerichte Aanpak (Harderwijk). The importance of the role of Rijkswaterstaat and its discrepancy with wildfire risk mitigation was also pointed out by Van Raffe (2011).

There is also a discrepancy concerning the removal of all branch- and topwood (Table 9-e). This is clearly something not wanted by the nature managers. From their perspective, branch- and topwood are considered valuable assets of ecosystems, so the policy is generally to keep it in the forest, for example after a logging. Fortunately, in most places the local fire department is already understanding of this practice, but it seemed to be quite a sensitive issue for the terrain managers, since it was often brought up (Staatsbosbeheer, Kroondomein Het Loo, Ermelo, Harderwijk).

In relation to prescribed burning (Table 9-f), there is also a bottleneck concerning the burning period. Prescribed burning is allowed in the period between December 1 to March 15, and to guarantee fire control, not more than 1 hectare per burning is allowed. For the safety region an extended burning period would be better, for planning reasons. For reasons of nature management this is not allowed, because of habitat and nest protection. The terrain managers are also not satisfied with the current legislation, because they want to be able to burn more than 1 hectare at a time. In places where prescribed burning is regularly and on larger scales used, prescribed burning turns out to be very beneficial for the ecosystems, so burning can also be seen as essential part of active nature management. For maintaining heathland it does however require intensive grazing after a burn, in order to suppress grasses from quickly replacing the heath. Some terrain managers do not see wildfire as a natural phenomenon belonging in Dutch nature. Others see it as an unavoidable phenomenon, that, for most often human reasons, sometimes exist. And other terrain managers even think that sometimes a (little) wildfire is beneficial for nature. For these, controlled and prescribed burning are available as tools for nature management.

The remaining four points (Table 9-a,d,g,h), about forest transformation, fire breaks and water accessibility, collaborative firefighting and controlled burning did not show a discrepancy between the safety sector and terrain managers, since they have little impact on the competing nature functions or can join functions already present in terrain management.

So yes, there are discrepancies between nature management and wildfire risk mitigation policies. These pivot around the different values of the red and green sector,

around the prioritization of the functions of nature areas compared to the safety from the wildfire risk and around the stakeholder involvement in the policy development process.

6.2 Discussion of methods

Every step of research should happen scrutinously, because it's a very delicate matter to try to describe reality in a few words. The part of reality you will examine, the lens with which you examine it, the kind of intervention you do to gather the results, the analysis through which the results go, the interpretation of those results and the reporting of the findings: they all deserve equal attention.

The choices made in the methodology can be discussed on several levels. On the level of the study the point can be made that this one case is not sufficient or general enough to represent the Netherlands as a whole. More regions could be studied to see what's different there compared to the Veluwe. However, since the Veluwe region has experienced many wildfires and since the two safety regions that cover the Veluwe are so-called 'expert regions' concerning wildfire management (Flohr & Van Ruijven, 2015) this was a good case for an exploratory research.

On the level of the methodology the choice for in-depth semi-structured interviews should be reconsidered. A somewhat more closed interview style might have resulted in more valid information. For this, a stricter interview guide tightly bound to the indicators in the conceptual framework would help. Instead of talking with the interviewee about wildfire risk management and trying to find some indications of, for example, openness to doubts and double-loop learning, the interview guide could also contain more explicit questions about these indicators. This would result in self-reports from the interviewees about these indicators in their organizations, which would be susceptible to their subjectivity. The implicit interview style was chosen because it was expected that this would give a more objective indication, although it is then sensitive to the subjectivity of the coder.[1]

Making two rounds of interviews would also have been more informative in this case. Because in exploratory research the research field is less known, the first few interviews can be used for determining this field, and the second round for more specific research. The current approach did however yield many case-specific details about the wildfire risk mitigation measures and the relationships between stakeholders, and was in that sense in-depth.

[1] A compromise between the weaknesses of both these styles is attempted by the Sense-Making Methodology by bridging the gap between theory and method and interviewer and interviewee (Dervin, 1999).

Double-loop learning and discussing doubts are potentially hard to see from the outside, through interviews.

A stricter interview guide could also have made the interviews shorter, and thus give time for more interviewees from more than the three dimensions now covered, thus enhancing saturation. With two interviews with the safety sector, and six with terrain managers, the regional or provincial nature policy dimension has been missed. Also, interviewing the other of the two safety regions that operate on the Veluwe could have brought in some additional information. The use of snowball sampling was also limiting in this regard, since it only brought in suggested stakeholders in the same sector of the interviewee.

With regard to the analysis, the coding process should be discussed. Singular coding is prone to errors, a point Mandryk et al. (2015) also have made. Unlike the interpretation of quantitative information to obtain the ranks, scoring qualitative data mainly depends on the researchers' judgment of the interviews with stakeholders and experts (Gupta et al., 2010). Misinterpretation of the information obtained in the interviews may lead to an incorrect score, and so a better score would be obtained by adding coding rounds and/or coders. This is a point of consideration for the planning of the empirical part of these types of research.

6.3 Discussion of theory

The theoretical choices in the research have a great impact on what you can find, and what you will see in your research. This section discusses the choices that have been made in this regard.

Firstly, the risk society (Beck, 1992; Beck, 1999) was used as a broad backdrop to the situation that has developed around the wildfire risk in the Netherlands. This theory was usable because it described general processes in society, which could be translated into indicators for a risk society. A more specific theoretical framework, for example, focusing on expertise development or risk perception could lead to more applicable practice-based conclusions, but would not provide such a complete view upon the way society deals with the wildfire risk. A drawback of the risk society theory is that it deals with very big and permanent risks. This research was in that regard a test if wildfires pose enough of a permanent risk to be indicating a risk society in the Netherlands, which was not completely the case. In a longitudinal study the risk society indicators can provide an interesting perspective on the risk perception of wildfire in the Netherlands.

Secondly, in the current research, only the dimension of learning capacity has been studied of the Adaptive Capacity Wheel (Gupta et al., 2010), implying that through studying this one factor, something could be said about the organizations' adaptive

capacity. Even though learning capacity is one of the three core dimensions, the validity of conclusions from learning capacity alone is in question, because variety and room for autonomous change are as important (Termeer et al., 2012). In addition, the Adaptive Capacity Wheel is a tool for system analysis (Bettini et al., 2015), and this study did not cover a complete system of organizations, but rather particular organizations that were not part of one institution or network.

Another aspect to the adaptive capacity wheel is the fact that by focusing on institutions, it reinforces the assumption that these institutions are essential for having societal adaptive capacity. Trying to evade that pitfall, an analysis that supersedes the institutional level would be required. One way of doing that is by following the Procedure for Institutional Compatibility Assessment (PICA) framework (Theesfeld et al., 2010 in: Mandryk et al., 2015). It would be interesting to apply that compatibility assessment to the wildfire risk mitigation policy field in the Netherlands, since it focuses more on institutional differences between, for example, the safety and the nature sector.

The current research found important differences in the policy development between the safety sector and the nature sector. The methodology assumed an organizational similarity between the stakeholder, while this may not have been correct. In this regard, it would be worth researching the differences of assessing policy development between higher and lower organizational levels. In the former, abstracter policies are developed, thus being better researchable by policy analysis theories. The lower organizational levels are more practice based and probably have other courses of and constraints to policy developments. Hypothetically, the difference between these two organizational levels determines the policy development analysis more than the policy cycle stages. A more practice-based policy analysis tool would be helpful in analyzing the policy development in nature management. This conclusion is also of importance to other environmental-governmental conflicts, since these easily cover multiple organizational levels.

CHAPTER 7

Conclusion

The main research question of this thesis is "What are the stakeholders' beliefs about the wildfire risk, and how are they collaborating in the policy production at the intersection of nature management and wildfire risk mitigation in the Netherlands, in particular with regard to the Veluwe?"

Wildfire is generally perceived as a real risk for the Veluwe, but also a natural phenomenon generally beneficial for nature. The societal feeling is easily influenced by the media and hypes of wildfire risk, which were inflated by the use of risk-indicating codes communicated by the safety region. Many interviewed stakeholders on the Veluwe are at least partly occupied with wildfires, because the large natural areas are a high-risk region in the Netherlands. The terrain managers have some experience with wildfires and are dealing with it in different ways. The safety sector stakeholders have the duty of increasing the safety in their region, and have been particularly occupied with wildfires since 2010 when wildfires became more intense in the Netherlands compared to the decades before.

The involvement of terrain managers with wildfire mitigation has always varied for locations and individuals, and some processes mitigating the wildfire risk have already been going on for decades, for example the forest transformation and diversification, which is generally also a long-term process. But for most terrain managers, wildfire mitigation effectively began when seven extra measures were introduced for (experimental) use in the Netherlands: the Gebiedsgerichte Aanpak ('area-specific approach'), compartmentalization, accessibility, fuel management, prescribed burning, collaborative wildfire fighting and controlled burning. The Gebiedsgerichte Aanpak is the overarching program in which several of the named measures might be used, depending on local circumstances. The area-specific approach of the Gebiedsgerichte Aanpak was new, and so was the collaboration with the involved terrain managers whose expertise was also needed. It has however not been ultimately tested yet: as of 2017 there has not been a wildfire in any area that was adapted.

The stakeholders received these new policies in various manners. All terrain managers were positive about the fact that they got formally involved, as advisor in the command chain of wildfire fighting. This improved every part of wildfire fighting. The collaboration needed for these policies was in most cases successful, and specific expertise of stakeholders was well used by the others.

Concerning the Gebiedsgerichte Aanpak, not every terrain manager agreed with the proposed measures, feeling that the approach was still too much from a safety perspective. This impacted implementation of the measures negatively. The discrepancies

between the safety and nature sectors can have their sources in different responsibilities, but are also personal and institutional. The green sector is responsible for all functions of their terrains, not only wildfire mitigation or safety, whereas for the red sector, safety is the core business. Personally, the stakeholders can have disappointing experiences with intersectoral collaboration. Institutionally, there were value differences, of which ecological ideas were the most prominent, but also policy compatibility issues, because of which it would be difficult to make a combined approach to the issue from the outset. These barriers to collaboration need more communication and training to be overcome by a growing trust. Collaboration depends on mutual trust and openness, which was not abundantly present in all relationships. The safety sector showed the learning capacity characteristics the most, and private terrain managers the least. A larger openness to doubts about their practice and increasing institutional memory are ways to grow this learning capacity and be more ready to necessary changes in the future.

Concluding, nature management and wildfire risk mitigation have in some ways both adapted and moved towards each other. This resulted in some mitigation policies being implemented which mostly seem effective up to now, and some personal and institutional barriers to collaboration.

Recommendations for the Dutch wildfire management

Firstly, informing the general public on the risks of wildfire needs to stay a high priority. This involves steady news year-round about firefighting exercises or procedures, and actively informing the media in cases of wildfire. First responsibility in this regard would lay with the safety sector, but when all wildfire risk stakeholders go about this, it gives an even more consistent view of the wildfire risk and might transpire the feeling that this risk really is multi-sectorally controlled.

Secondly, for cases when adaptivity is imperative, such as climate change, it is important for terrain managing organizations and (local) governments to grow in internal scrutiny, and external vulnerability about their own assumptions and practice. This cannot only increase trust, double loop learning, but might also increase internal bonding, institutional memory and external collaboration.

Thirdly, the implementation of wildfire risk mitigation policy performs best as a continuous and collaborative effort, which iteratively evaluates the effectiveness of the measures and exercises the protocols of the management and executive levels of organizations. Nature is constantly changing and growing, water availability might change, people in organizations and their experience change, and new knowledge can lead to new ideas for nature management and wildfire risk mitigation. There might

also be long-term consequences that weren't foreseen when the policy was designed. When this is ensured, the Gebiedsgerichte Aanpak will be very successful, and may lead to further collaboration of the nature management and safety sector. With regard to the form, Brennan (2016) encourages that risk regions have 'fire boards', similar to the existing 'water boards', in which local relations and knowledge, experience and expert knowledge all work together.

Finally, with regard to research, it would be worth researching the differences of measuring policy development between higher and lower organizational levels. In the former, abstracter policies are developed, thus being more researchable by policy analysis theories. The lower organizational levels are more practice based and probably have other courses of and constraints to policy developments.

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Appendices

This chapter provides some sources that are referenced to in the text, and additional research about the Veluwe which is not included in the main thesis.

A.1 Stakeholders (Van Raffe, 2011)

Government/ policy makers

- European Union

National government:

- Ministries of Economic Affairs (EZ), Housing, Spatial Planning and the Environment (VROM), Infrastructure and the Environment (V&W), Security and Justice (Justitie) and Interior and Kingdom Relations (BZK)
- Provinces
- Municipalities
- Water boards
- Bosschap

Operational services:

- Fire department (Brandweer)
- Police
- Regional Medical Assistance Organization (GHOR)

Other parties

- Owners & managers
- Recron
- Inhabitants & users
- Prorail
- Rijkswaterstaat
- Common Forest Insurance (Onderlinge Bossen Verzekering)
- Education
- Cooperations

A.2 Literature using 'risk society' as keyword

As of May 12th, 2017. All articles in Scopus are considered, categorised by academic field.

Academic field	**# articles**	%
Social Sciences	224	49%
Arts and Humanities	49	11%
Environmental Science	33	7%
Medicine	30	7%
Business, Management and Accounting	28	6%
Engineering	20	4%
Economics, Econometrics and Finance	13	3%
Earth and Planetary Sciences	10	2%
Psychology	10	2%
Computer Science	9	2%
Nursing	27	6%
Total	**453**	**100%**

A.3 Interview guide (in Dutch)

[Introduce the topic, goal and structure of interview]

1. Wat is uw functie?
2. En wat is daarin uw relatie tot natuurbranden?
3. Welke ervaring heeft u met natuurbranden op de Veluwe?
4. Beschouwt u een natuurbrand als een natuurlijk proces?
5. Wat zijn de gevolgen van natuurbrand voor de natuur op de Veluwe?
6. Wat zijn de gevolgen van natuurbrand voor de fauna?
7. Hoe wordt gehandeld in geval van natuurbrand? Welke actoren krijgen welke verantwoordelijkheden?
8. Wat is de rol van het natuurbeheer in geval van natuurbrand?
9. Wat vind u van hoe dit proces? Zijn de verantwoordelijkheden terecht zo verdeeld?
10. Hoe wordt omgegaan met de evaluaties en ervaringen van eerdere bosbranden?
11. Welke doelstelling(en) heeft het beleid en beheer van uw natuurgebied?
12. Hoe is het natuurbeheer en -beleid tot nu toe betrokken op natuurbrandbestrijding? (Sinds wanneer) is er samenwerking? Op welk niveau?
13. Waar bestaat het risico van natuurbranden op de samenleving uit?
14. Hoe wordt het risico nu opgevangen in uw gebied? Is dat realistisch voor de toekomst?
15. Wordt de risico-index / RIN ingezet, en is dat voldoende?
16. Zijn er plekken op de Veluwe waar natuurbrand géén of een beperkt risico vormt?
17. Hoe wordt er vanuit uw gebied gecommuniceerd over het risico van natuurbrand?
18. Sluiten het veiligheids- en natuurbeleid op elkaar aan? Wordt u beperkt door het veiligheidsbeleid op de Veluwe, of andersom?
19. Welke preventieve maatregelen neemt u tegen natuurbranden?
20. Welke maatregelen buiten uw verantwoordelijkheid zouden er genomen kunnen worden om het risico van natuurbranden te verminderen?

A.4 Wildfire ecosystem effects

Due to its irregular and extreme nature, wildfire can potentially (depending on its intensity) have big effects on different levels in an ecosystem. These effects are described by level below.

Ecosystem From an ecosystem perspective a wildfire always brings the forest in an earlier succesion state through rejuvenation and clearing the dead wood, both standing and on the forest floor. It is also often seen that previous vegetation communities returns after a middle-long period (Kemmers et al, 2005; Varner et al., 2005). Despite popular fears of loss of wildlife, Brennan et al. (1998) show that areas excluded of fire show actually a decrease of wildlife diversity in the long term, pointing in the direction of a positive effect of at least some wildfire on the wildlife diversity.

Gaps By burning or killing some trees a wildfire creates gaps in closed forest systems, allowing for rejuvenation and diversification of the forest.

Tops Crown fires can completely destroy the treetops of a forest. In general the lowest branches hang lower in deciduous trees than conifers, so around deciduous trees chances are bigger that a ground fire develops into a crown fire (Stuiver and Verbesselt, 2011). But if the fire remains on the ground, the tops are mostly spared and shelterwood system emerges.

Stems Younger trees are more vulnerable to fire, especially at bigger stem heights, due to their thinner bark and lower crown base (Valor et al., 2015). There are also differences between conifers and deciduous trees, as the latter are relatively dryer and contain the easily combustible resins, making them burn more easily (Stuiver and Verbesselt, 2011).

Roots In frequently burned forests, roots are not affected by wildfire, because they tend to grow less into the topsoil. Fire exclusion has created an accumulation of topsoil layers where roots also grow, so in a first wildfire after exclusion these roots are threatened (Varner et al., 2005).

Soil Small and moderate wildfires enrich the mineral composition of soils, mainly through fertilization from ash and carbon (Brennan et al, 1998; Certini, 2005; Kemmers et al., 2005). However, more intense wildfires most often have negative effects on the soil: organic matter is burned, the structure of the soil can be severely damaged and the bacterial and invertebrate communities necessary for healthy soils might be reduced in quantity. These effects are however not irreversible (Certini, 2005).

A.5 Wildfires in the Netherlands, 1995-2017

Date	Location	Area	Source
04-aug-95	Valkenswaard	4	https://www.digibron.nl/search/detail/012de63b219867c9aedbc90e/heidebrand-in-brabant-en-belgisch-limburg/5
14-aug-95	Kootwijk	150	https://www.nrc.nl/nieuws/1995/08/14/bosbrand-langs-a1-smeult-nog-na-7277357-a47087[1]
20-apr-96	Brabant, Veluwe, Limburg	78	https://www.nrc.nl/nieuws/1996/04/22/droogte-leidt-tot-veel-branden-in-bos-en-hei-7307413-a693147
22-apr-96	Kalmthoutse Heide	60	https://www.nrc.nl/nieuws/1996/04/22/droogte-leidt-tot-veel-branden-in-bos-en-hei-7307413-a693147
18-jun-96	Veenendaal	8,5	https://www.digibron.nl/search/detail/012de40135b855b3ff4b67a0/felle-bosbrand-bij-veenendaal
26-jun-96	Apeldoorn	2	https://www.digibron.nl/search/detail/012de40de70d2f184a4fef77/bosbrand-langs-a-verwoest-hectare-heide/1
25-apr-97	Hoog Soeren	3	https://www.digibron.nl/search/detail/012de16527a772d2218e7fc8/windkracht-wakkert-brand-hoog-soeren-aan/5
29-apr-99	Nijverdal	5	https://www.digibron.nl/search/detail/012ddcde56aa67a888a7bcee/tunnel/2
29-apr-99	Rozendaal	25	https://www.digibron.nl/search/detail/012ddcdcc86f6dc300521bd9/heidebrand-aan-rand-veluwe/1
06-mei-99	Tilburg	4	https://www.digibron.nl/search/detail/012ddce7dfe61ed2da72b67b/tilburg-heeft-handen-vol-aan-bosbranden

[1] 1995: Kootwijk and Nieuw-Milligen, very close to Kroondomein Het Loo and jumped the broad highway A1 (Kroondomein Het Loo). Water availability was a problem then. This fire endangered a highway, an overhead power line and a camping. 10 years later Staatsbosbeheer was very glad about the fire, because it had good effects on the ecosystem (VNOG) and has restored fantastically since then (Harderwijk).

27-mei-99	Drunen	3	https://www.digibron.nl/search/detail/012ddd08a306e87379077684/aanpak/3
10-apr-00	Someren	10	https://www.digibron.nl/search/detail/012dd092fd82cdddb7cf0a63/ongeval/5
07-apr-02	Koekange	1	https://www.digibron.nl/search/detail/012dcbe4c25efd72d5a2db16/winkelier-genaar-pakt-twee-dieven/12
29-mei-02	Rheden	2,5	https://www.digibron.nl/search/detail/012dcc3ed67c52a4404f68e3/heidebrand-na-explosie-fosforbom/1
16-apr-03	Tilburg	5	https://www.digibron.nl/search/detail/012dc9baa9b417bb9cfe9160/bosbrand-in-tilburg-en-dronten/4
17-apr-03	t Harde	100	https://www.digibron.nl/search/detail/012dc9bbbc2b1852df10352d/chinook-blust-voor-het-eerst-heidebrand-op-de-veluwe/9
29-jun-03	Weert	1	https://www.digibron.nl/search/detail/012dca2b9f7ab985c60ee415/heidebrand-op-altweerterheide-bij-weert/0
05-aug-03	Rozendaal	1	https://www.digibron.nl/search/detail/012dca593ffd208802060731/bosbrand-mogelijk-aangestoken/1
16-mei-04	Terschelling	40	https://www.digibron.nl/search/detail/012dc635e22fee2d148b5d1c/bosbrand-terschelling-verwoest-hectare/2
06-mei-06	Uddel, Kroondomein Het Loo	150	https://www.digibron.nl/search/detail/012dc23b21a97bb733a01206/vuurgevecht-op-de-veluwe/1
25-mei-09	Nuenen	4	https://www.digibron.nl/search/detail/012dbc1de31445c12b03407e/jongen-aangehouden-voor-heidebrand/3
02-jun-09	Exloo	3	https://www.digibron.nl/search/detail/012dbc2867ae09296a65e586/drie-hectare-heide-afgebrand-in-drenthe/14
28-aug-09	Schoorl	150	https://www.parool.nl/binnenland/brand-in-schoorlse-duinen-onder-controle~a265186/

16-sep-09	Bergen	25	https://www.nu.nl/algemeen/2083583/bos-brand-bergen-controle.html
22-okt-09	Schoorl	9	https://www.parool.nl/binnenland/brand-in-schoorlse-duinen-onder-controle~a265186/
20-apr-10	Hoog Soeren	40	IFV, 2014
20-mei-10	Leusderheide	48	https://www.nu.nl/binnen-land/2250895/forse-natuurbrand-leusder-heide.html
02-jul-10	Strabrechtse Heide[1]	200	IFV, 2014
25-apr-11	Bovensmilde	100	http://www.112groningen.nl/Gronin-gen/nieuws/13498/112ned-100-hectare-na-tuurbrand-bij-bovensmilde-2x-video.html
28-apr-11	Fochteloërveen	100	http://dieren.blog.nl/natuur-in-neder-land/2011/04/30/brand-fochteloerveen-deci-meert-reptielenpopulatie
02-mei-11	Schoorl[2]	200	https://www.nu.nl/binnenland/2505486/wind-hindert-blussen-schoorlse-duingebied.html
03-jun-11	Aamsveen	100	IFV, 2014
23-mrt-12	Loonse en Drunense Duinen, Drunen	3	http://www.omroepbra-bant.nl/?news/171620522/Drie+hec-tare+in+as+na+brand+in+Loonse+en+Dru-nense+Duinen.aspx
01-apr-12	Radio Kootwijk[3]	100	http://112vallei.nl/page/Nieuwsde-tail/13654/grote-heidebrand-bij-radio-koot-wijk
24-mrt-13	Hoog Soeren	2	https://www.nu.nl/binnen-land/3379295/brandweer-massaal-uitgerukt-brand-veluwe-.html
26-mrt-13	Leenderbos	150	http://www.omroepbra-bant.nl/?news/190842832/Zeer+grote+hei-debrand+Leenderbos+onder+con-trole+groot+natuurgebied+verloren.aspx

[1] At this wildfire a terrain manager got injured by smoke inhalation and was rushed to an hospital. That shouldn't happen, the terrain managers should only support in the safe zone (Staatsbosbeheer).
[2] With help from helicopters. (IFV)
[3] 100 hectares was on fire, but surrounded by roughly a 1000 hectares of heathland (Staatsbos-beheer).

02-apr-13	Cartierheide, Hapert	4	http://www.omroepbra-bant.nl/?news/191232572/Brand+op+Car-tierheide+in+Hapert+verwoest+vier+hec-tare+heide.aspx
06-mrt-14	Ginkelse heide, Ede	9	http://www.112vallei.nl/page/Nieuwsde-tail/20754/natuurbrand-ginkelse-heide-snel-onder-controle
10-mrt-14	Loonse en Drunense Duinen, Drunen	50	http://www.omroepbra-bant.nl/?news/2078171023/Grote+bos-brand+Loonse+en+Drunense+Dui-nen+is+uit,+ongeveer+50+hectare+ver-woest.aspx
17-apr-14	Mastbos, Breda	10	https://www.nu.nl/binnenland/3754874/tien-hectare-bos-in-brand-bij-breda.html
20-apr-14	NP De Hoge Veluwe	350	IFV, 2014[1]
22-jun-14	Waalre	1,5	http://www.omroepbra-bant.nl/?news/213020232/Anderhalve+hec-tare+gras+afgebrand+bij+bos-brand+in+Waalre,+sein+brand+mees-ter+gegeven.aspx
13-mrt-15	Fochteloërveen	100	https://www.nu.nl/binnen-land/4010421/grote-natuurbrand-in-fochte-loerveen-in-drenthe.html
19-mei-15	Chaam	60	https://www.nu.nl/binnen-land/4050651/grote-natuurbrand-in-bossen-bij-brabantse-chaam.html
06-mei-16	Hoog Soeren	7,5	https://www.transport-on-line.nl/site/71186/heidebrand-bij-hoog-soe-ren-video/
08-aug-16	Schoorl	1	https://www.hartvannederland.nl/top-nieuws/2016/grote-duinbrand-bij-schoorl/
09-apr-17	Arnhem	2	https://www.gelderlander.nl/arnhem/brand-weer-blust-felle-natuurbrand-aan-rand-arn-hem~a8b579b4/

[1] April 20, 2014: 320 hectare. Two helicopters were used here (that was the latest time they were used). This was almost an uncontrollable wildfire (IFV), and also the second biggest registered wildfire in the Netherlands. This one was probably also lighted by somebody, but real evidence hasn't been found. (NP De Hoge Veluwe).

20-apr-17	Ugchelen	4	https://www.gelderlander.nl/binnenland/heidebrand-in-ugchelen-snel-onder-controle~af039a9e/
30-apr-17	Gasselte	2,25	http://www.dvhn.nl/drenthe/Brandweer-heeft-heidebrand-bij-Gasselte-onder-controle-22176190.html
30-apr-17	Denekamp	4	https://nos.nl/artikel/2170918-man-opgepakt-voor-natuurbranden-in-twente.html
26-mei-17	Bornerbroek	1,7	https://www.hartvannederland.nl/nieuws/2017/natuurbrand-bij-bornerbroek-onder-controle/
27-mei-17	Lippenhuizen	1	http://www.lc.nl/friesland/Brandweer-uitgerukt-voor-heidebrand-Lippenhuizen-22244184.html
12-jun-17	Oirschotse Heide	3	http://www.omroepbrabant.nl/?news/2659461213/3+hectare+afgebrand+op+Oirschotse+Heide.aspx
19-jun-17	Appelscha	1	https://www.nieuweoosterstellingwerver.nl/nieuws/dorpen/499027/brand-verwoest-hectare-natuurgebied-in-appelscha-fotoreportage.html
22-jun-17	Asten	2	http://www.omroepbrabant.nl/?news/266408962/Bliksem+veroorzaakt+grote+natuurbrand+in+Nationaal+Park+De+Groote+Peel.aspx
22-jun-17	Mariapeel, Deurne	21	https://www.telegraaf.nl/nieuws/225386/brand-mariapeel-geblust
26-jun-17	Axel	3	https://www.telegraaf.nl/nieuws/230931/natuurbrand-mariapeel-opgelaaid
10-jul-17	De Malpie, Valkenswaard	60	https://www.hartvannederland.nl/nieuws/2017/natuurbrand-bij-valkenswaard-geblust-60-hectare-verwoest/

Table 10: Reports of wildfires found in the media between 1995 and 2017. Only wildfires of at least 1 hectare are accounted for.

A.6 Governance theories

Governance is a concept used to describe the governing of the public domain moving from simply the government to participation of non-governmental actors in this governing[1] (Bache & Flinders, 2004). In this process many complex networks of public and private and (inter)national to local actors can form, and depending on conceptual frameworks, different networks will be seen. Many of these conceptual frameworks are (being) abstracted[2], for example 'adaptive governance' and 'interactive governance'.

Adaptive governance focuses more on answering the question of how to ensure that governance is able to cope with changing and uncertain problems (Triyanti and Marfai, 2017). Abrams et al. (2015) describe adaptive governance for example as a process that can build community resilience to wildfire. This potential for learning and adaptation is the best when the operational, collective and constitutional levels are aligned, have good communication and relationships, are receptive for new information and flexible to adapt in response (Abrams et al., 2015).

Another interesting governance approach is interactive governance, also called 'multi-stakeholder participation'. This approaches policy making less institutionalized but more as ad-hoc participatory trajectories. This approach is being described as having more room for understanding the local situation and use of local knowledge (Roth et al., 2017).

Multi-Level Governance (MLG)

Multi-dimensional governance is another governance approach which emphasizes that the central government authority is not only decentralized, but also spread towards the non-public actors such as the private sector and NGOs. This can be split up into two dimensions: the vertical shifting of governance towards actors on supranational or subnational levels and a horizontal shift from public to private, societal or judicial actors (Kersbergen & Van Waarden, 2004; Kluvankova et al. 2009; Andersson & Keskitalo, 2018; Figure 2).

Hooghe & Marks (2001) distinguish two types of MLG: Type I is the general-purpose, non-intersecting. The best example of it is federalism (in the USA or Germany), which creates subsidiary governments on lower levels that are responsible for all tasks in its jurisdiction.

[1] Another way of looking at this is as a 'displacement of government' out of the center of power, see Pauly et al. (2015).
[2] See: Kooiman, J. (1999). Social-political governance: overview, reflections and design. *Public Management an international journal of research and theory*, 1(1), 67-92 and Bevir, M. (2008). *Key concepts in governance*. London, UK: Sage.

Type II is the creation of flexible, task-specific and overlapping associations of organizations and/or municipalities. These might be specific in task and/or duration. An example of this are the so-called 'Zweckverbände' in Germany and Switserland, which can best be translated to "special purpose associations of multiple municipalities" (Liesbet & Gary, 2003). This could be seen as a more institutionalized version of the 'interactive governance', described in the above section.

This type II MLG is also what is described about the British state as "an increasingly complex range of inter-governmental relationships (public) of shifting and opaque jurisdictional boundaries together with a redefinition of state-society relations" (Bache & Flinders, 2004). This trend in Britain is also seen more in general: there is a historical shift from hierarchical (type I) to network (type II) governance. In the Netherlands the type II MLG is also very prevalent compared to other countries, because of the corporatist tradition (Pauly et al., 2017). The fact that these are complex networks make it harder to create conditions for adaptation actions[1] (Andersson & Keskitalo, 2018).

Governance position of stakeholders

All organizations function in different levels of the governance arena (see Figure 10). Rijksvastgoedbedrijf, IFV, the safety sectors (VNOG) and municipalities are strictly public institutions, and differ only in level of operation. Rijksvastgoedbedrijf and IFV are national institutions, the VNOG is regional and the municipalities are of course local.

Staatsbosbeheer is less public, since it is privatized, but not completely: it still executes a governmental task. The NP De Hoge Veluwe is more private than other national parks in the Netherlands since it doesn't get funding from the government but funds their running costs mainly through entrance fees. Kroondomein Het Loo is a private estate, though part of it (palace Het Loo) is state-owned, and the Kroondomein Het Loo (the forests) are on loan to the state.

[1] See: Keskitalo et al. (2016)

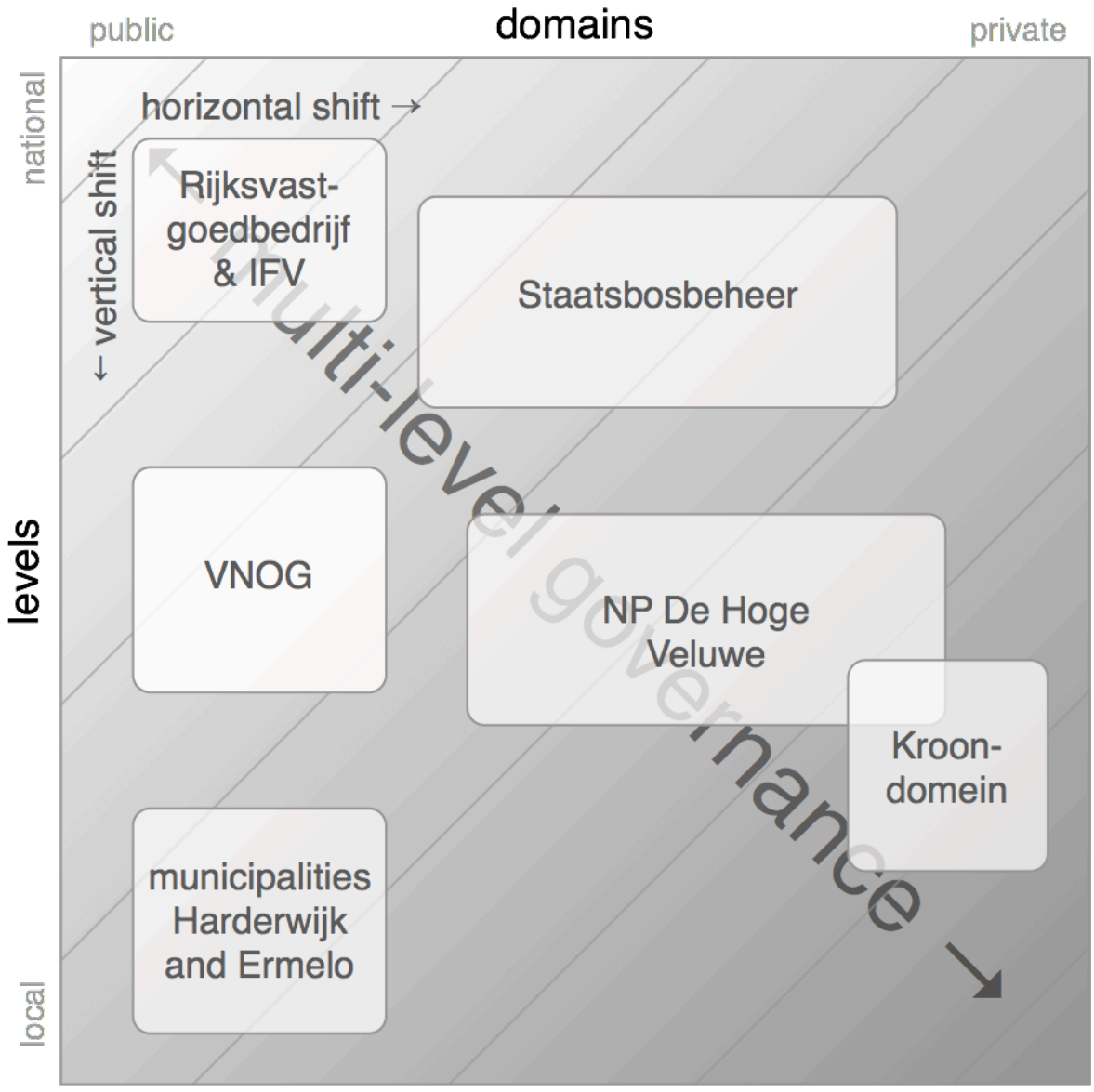

Figure 10: Approximate position of actors in the governance arena

A.7 Veluwe: geology, soils and habitat types

The Veluwe in a geophysical sense is laid upon the largest terminal moraine system in the Netherlands with heights up to 110m. This has created sandy soils with deep groundwatertables. The most common soil types are podzols with coarse or loamy fine sand, entisols with loamy fine sand and mollisols with loamy fine sand[1]. Its ecosystems are important for nine habitat types in the Netherlands (see Table 11).

Natura 2000 code	Description
2310	Dry sandy heaths with Calluna and Genista
2330	Inland dunes with open Corynephorus and Agrostis
3160	Natural dystrophic lakes and ponds
4010A	Northern Atlantic wet heaths with Erica tetralix
4030	European dry heaths
5130	Juniperus communis formations on heaths or calcareous grasslands
6230	Species-rich Nardus grasslands, on siliceous substrates in submountain areas
7110B	Active raised bogs
9190	Old acidophilous oak woods with Quercus robur on sandy plains

Table 11: Habitat types for which the Veluwe is important (Bijlsma et al., 2008)

[1] "Bodemkaarten." *BISNederland*, maps.bodemdata.nl/bodemdatanl/index.jsp.