



A Network-wide visualization of the implementation of the Global Strategy for Plant Conservation in Brazil

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Abstract

This paper describes a visualization approach of the existing network available in Brazil to achieve the targets of the Global Strategy for Plant Conservation (GSPC) for 2020 in Brazil. The approach uses the Brazilian National Biodiversity Strategies and Action Plans and other key documents to identify and map institutions, roles and actions related to each of the GSPC targets. The visualization was generated using the Gephi, an open source software for exploring and manipulating networks.

The visualization presented shows some GSPC targets supported by an effective network of institutions, but also GSPC targets that lack of proper support. This visualization approach may be useful to indicates gaps, opportunities for new actions and areas where network linkages may be extended to achieve the GSPC targets more fully in other countries too.

Key words: Brazil, GSPC, network visualization, plant conservation.

Resumo

Este artigo descreve uma abordagem de visualização da rede existente para atingir as metas da Estratégia Global de Conservação de Plantas (GSPC) para 2020 no Brasil. A abordagem utiliza as Estratégias e Planos de Ação Nacionais de Biodiversidade do Brasil e outros documentos-chave para identificar e mapear instituições, papéis e ações relacionadas a cada uma das metas do GSPC. A visualização foi gerada usando o Gephi, um software de código aberto para explorar e manipular redes.

A visualização alcançada mostra algumas metas GSPC suportadas por uma rede eficaz de instituições, mas mostra também metas GSPC com uma falta de suporte adequado. A abordagem de visualização pode ser útil para indicar lacunas, oportunidades para novas ações e áreas nas quais os vínculos de rede podem ser estendidos para atingir plenamente as metas do GSPC em países comprometidos.

Palavras-chave: Brasil, GSPC, visualização de redes, conservação de plantas.

Introduction

In August 2017, the Brazilian National Botanical Congress held a symposium entitled “2020 GSPC Targets: state of the art and future perspectives” where twelve speakers discussed and reviewed approaches towards the achievement of the sixteen targets of the Global Strategy for Plant Conservation (GSPC) in Brazil by 2020. The GSPC was originally adopted by the Parties to the U.N. Convention on Biological Diversity (CBD) in 2002. It was updated and revised in 2010, with targets set to be achieved by 2020. The GSPC’s targets are output oriented, specific and measurable. They address the conservation

needs of wild plants, as well as those of cultivated crops, both in the wild and in managed lands and landscapes.

To assess and review the 16th GSPC target, “Institutions, networks and partnerships for plant conservation established or strengthened at national, regional and international levels to achieve the targets of this Strategy” in its national context, we transformed the target into a question as follows: “[What] Institutions, networks and partnerships for plant conservation were established or strengthened at national and regional levels to achieve the targets of this Strategy?”.

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To answer this question, we use a network visualization tool, to build up, analyze and visualize the existence of a network of institutions, initiatives and actions dedicated to achieving the GSPC targets.

With the aim of understanding networks, the visualization of large graphs has been developed for many years in many successful projects. Visualizations are useful to leverage the perceptual abilities of humans to find features in network structure and data (Bastian & Jacomy 2009).

The use of such a visualization tool to consider the GSPC implementation provides a valuable means of highlighting areas where progress has been most substantial, or where there are critical gaps in networks or existing actions.

Methodology

To build up the network visualization, the first step was to identify and map relationships between one agent, one action or initiative, and the specific GSPC target as the basic structure of the network (Fig. 1).

In this basic structure, the “Agent” represents an institution or agency that takes an active role or produces a specific effect on the related action or initiative. The “Action or Initiative” represents a set of activities taken by the Agent towards the achievement of the GSPC Targets.

A review of the literature was undertaken to identify documents, reports, and articles related to GSPC targets in Brazil. The review highlighted that literature on GSPC implementation in Brazil is scarce and only the following references were noted: (Forzza *et al.* 2012) (Forzza *et al.* 2016) (Teixido *et al.* 2017) (Zenni, Dechoum

& Ziller 2016) (Ziller *et al.* 2007) (da Costa *et al.* 2016) (da Costa *et al.* 2017). Therefore, we decided instead to explore the National Biodiversity Targets (NBT) expressed in the National Biodiversity Strategies and Action Plans (NBSAP) (Ministério do Meio Ambiente 2017), thereby allowing us to build up a relationship map between the NBT and the corresponding GSPC targets. The result of this mapping can be seen at Table 1. The visualization of this relationship can be seen at Figure 2. The majority of the GSPC targets can be matched well with existing NBT targets, and vice versa.

In this mapping, we found seven NBTs that are without a relationship with the GSPC targets (Targets 2, 3, 6, 10, 16, 17 and 20); and two GSPC targets without a relationship with the NBTs (Targets 15 and 16) Since the National Biodiversity targets are strongly based on the Aichi Biodiversity Targets and not specifically on the GSPC, it is not surprising that there was not a complete match between them.

The NBSAP document brings a set of actions associated with each NBT, and one or more agents responsible for the action. The NBSAP actions were filtered to select just those actions directly related to plants, and those where the responsible agent was cited. Therefore, only a subset of actions present in the NBSAP was considered, as seen at Table 2.

Building the tables

Two tables were built as a result of the systematization of the findings from the cited documents: nodes and edges (Dalcin 2017). The “nodes” represents the agents, initiatives or actions and targets; and the “edges” represents the relationship between two nodes (Fig. 3).

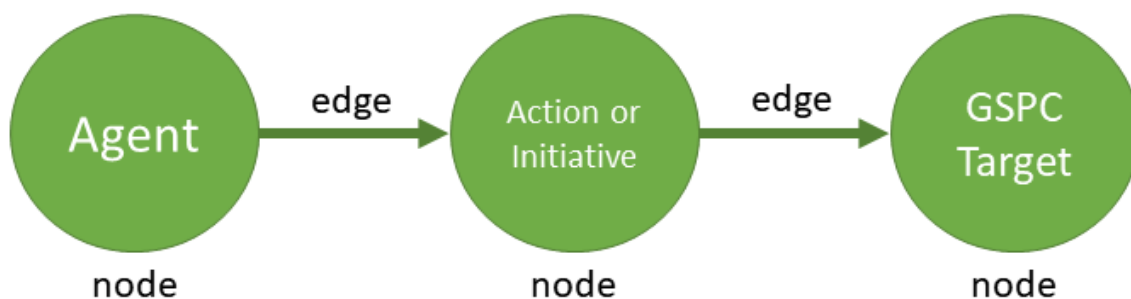


Figure 1 – The basic structure of the network: agent, actions or initiative and GSPC Targets.

Table 1 – Mapped relationship between NBT and GSPC Targets.

GSPC	National Biodiversity Targets
Target 1	Target 19
Target 2	Target 12
Target 3	Target 19
Target 4	Targets 5, 11 and 14
Target 5	Targets 5 and 11
Target 6	Targets 7 and 8
Target 7	Target 12
Target 8	Targets 12, 13 and 15
Target 9	Target 13
Target 10	Target 9
Target 11	Target 12
Target 12	Target 4
Target 13	Target 18
Target 14	Target 1
Target 15	-
Target 16	-

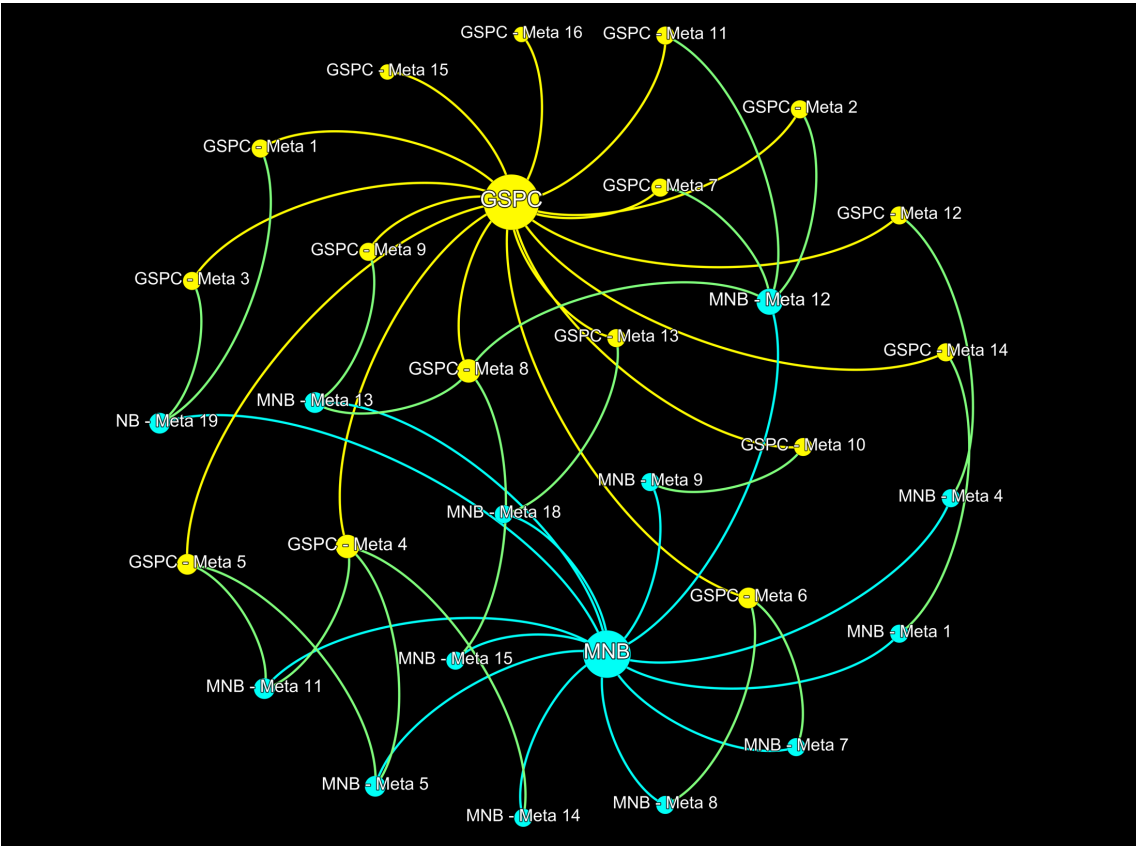
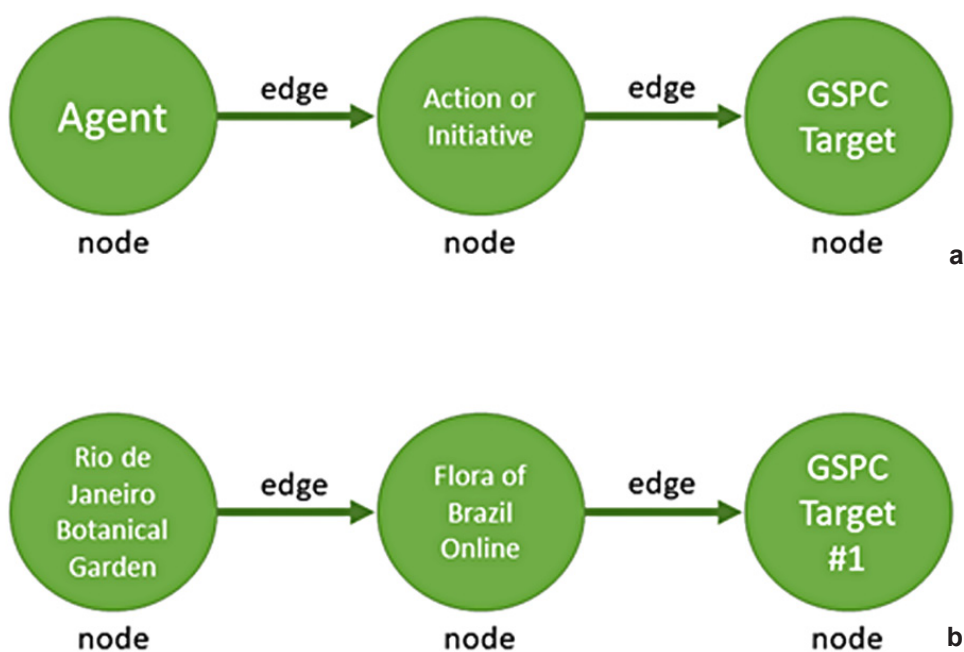


Figure 2 – Relationship between National Biodiversity Targets (MNB) and GSPC Targets.

Table 2 – National Biodiversity Targets and actions related with GSPC targets, compiled from Ministério do Meio Ambiente, 2017.

National Biodiversity Targets	Nº of actions	Nº of actions related with GSPC and with responsible agent cited
Target 1	60	52
Target 2	34	-
Target 3	41	-
Target 4	26	12
Target 5	38	32
Target 6	20	-
Target 7	60	44
Target 8	22	6
Target 9	28	24
Target 10	8	-
Target 11	90	84
Target 12	34	27
Target 13	18	14
Target 14	34	19
Target 15	55	35
Target 16	18	-
Target 17	9	-
Target 18	29	16
Target 19	80	77
Target 20	10	-
TOTAL	714	442

**Figure 3** – a. the basic structure of the network; b. an example of nodes and edges.

The following attributes were defined to nodes and edges, and filled on the tables:

Nodes

Id: Unique number that identifies the node

Label: Short name of the node

Cat_node: Category of the node

Descrição/nome: Description or name of the node

Edges

Id: Unique number that identifies the edge

Source: Source node of the relationship

Target: Target node of the relationship

Cat_edge: The category of the edge

Fonte: source of information that testifies the relationship

Nodes and edges were categorized also, as follow:

Category of nodes

Acao: Actions or initiative directed to the achievement of the National Biodiversity Targets or GSPC Targets. Those actions or initiatives came from the cited literature as a commitment taken by at least one agent

Agencia: Governmental or non-governmental agencies. In the survey, only one agent was classified as an agency - the United Nations Environmental Program office in Brazil.

Ensino e Pesquisa: Universities and research institutions.

Fomento: Agents from different sectors which acts at the network as funders of one or more action.

Gov: Governmental institutions (except universities and research institutions).

Herbario: Herbarium. This category represents an herbarium as an independent unit, even considering that most of the herbariums belong to a research institution, a botanic garden or a university. This category was created to represent initiatives strongly related to GSPC targets 1 and 3.

Iniciativa: Projects or programs, uni or multi-institution, directly related to GSPC Targets. One typical example of this category is the “Flora of Brazil Online” initiative - a multi-institutional effort to achieve the GSPC Target one in Brazil.

Jardim Botânico: Botanic gardens as an independent unit, regardless of their institutional links or association with the governmental, non-governmental or private sector.

Meta-GSPC: GSPC Target.

Meta-Nac: National Biodiversity Target.

ONG: Non-governmental environmental or conservation organizations.

Privado: Private organizations.

UC: Protected area, regardless of their institutional links or association with the governmental, non-governmental or private sector.

Category of edges

Acao: Represents an action taken by one node (agent) to achieve one GSPC or National Biodiversity Target.

Coordenacao: Represents a role of coordination from a node (agent) over an action.

Dados: Represents a data flow from one node (agent) to an initiative.

Financeiro: Represents financial support from one node (mostly a funding agency) to support an initiative or action.

Gestao: Represents a management role from one node (agent) over an initiative. This relationship recognises the administrative and fund management by one agent, generally an NGO.

Infraestrutura: Represents the infrastructure provided by one node (agent) to one initiative or target.

Institucional: Represents the institutional relationship between two nodes (agents). For example, a research institute that belongs to the Ministry of Science, Technology, and Innovation.

Meta-Acao: The relationship between one target and the actions proposed to achieve it.

Metas relacionadas: The relationship between a GSPC Target and a National Biodiversity Target.

Missao: Represents that the target is part of the mission of the agent.

Network: Represents a formal network relationship, in this case, the relationship of the National Botanic Gardens Network and a set of national botanic gardens.

Tecnico: Represents the technical knowledge or skill provided by the staff of one node (agent) to an initiative or action.

As the result of the systematization, the nodes table sum up 965 nodes, and the edges table sum up 1,664 edges. Both tables can be downloaded at the Rio de Janeiro Botanical Garden Institutional Data Repository, following the link <https://ckan.jbrj.gov.br/dataset/gspc_br>.

Building the visualization

The two tables – nodes and edges – and the visualizations were built using the software Gephi (Bastian & Jacomy 2009), version 0.9.1.

The network visualization for each GSPC target was built by filtering of the union of the

“Ego Network” of each GSPC and related NB Targets or specific initiative. Ego networks are comprised of a focal node (called ego) and the nodes with which the ego is directly connected. These nodes to whom ego is connected are referred to as “alters” (Prell 2012). The “depth” of the “Ego Network Settings” was set for “two” (levels), for the GSPC targets and related National Biodiversity Targets. Directly related initiatives were added to the filter with the “depth” of “one”. The option “with self” was set as “checked”, following the default option of Gephi tool.

The “Layout” of the visualization was built using the algorithms “Force Atlas 2” (Jacomy, Venturini, Heymann & Bastian 2014), added with the “No Overlap” and “Expand”, when necessary, for better visualization.

Results

In Table 3 below, we can see a summary of the number of actions and nodes, by category, related to each GSPC target and their related National target. The ratio between the agents (institutions, projects, programs, initiatives, fund agencies, etc.) committed to the target to be achieved and the numbers of actions related to the target were calculated and shown in the table with the intention to show the level of institutional commitment towards each GSPC target.

In Figure 4 below, we can see the number of unique institutions in the network, by type. Universities and research institutions, together with herbaria, represent 59,6% of the institutions engaged in the achievement of GSPC target actions. Those agents are present in the network mainly related to the targets 1 and 3.

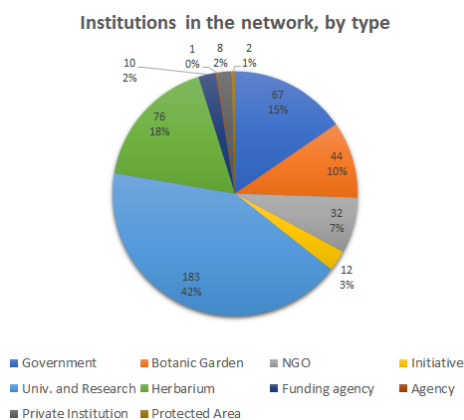


Figure 4 – No. of institutions, by type.

Figure 5 below shows the number of relationships (edges) in the network, by type. The “Action” edges represent the relationship between one institution and one action or initiative. The “Target-Target” edges represent the relationship between National Targets and GSPC Targets. The “Action-target” edges represent the relationship between the National Biodiversity Targets and their actions, proposed at the National Biodiversity Strategy and Action Plan.

Fourteen visualizations were produced, one for each GSPC target that had a relationship with the National Biodiversity Targets, and two additional visualizations showing the complete network, as we can see below.

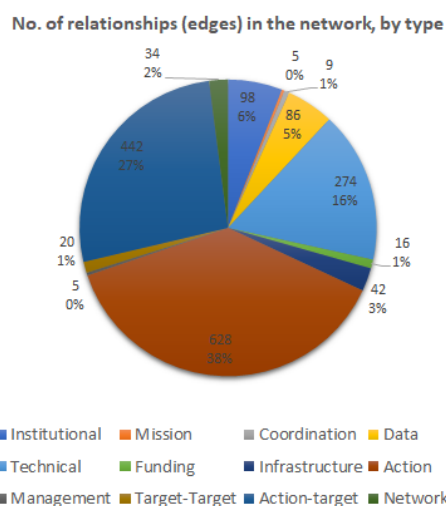


Figure 5—Nº. of relationships (edges) in the network, by type.

Target 1 - An online flora of all known plants

National Biodiversity Targets related: 19

Actions: 77

The Target 1 network visualization (Fig. 6) shows a strong initiative – Flora of Brazil 2020 (FB2020) – exclusively dedicated to achieving the target. Other strong initiatives related, allied to a coordination institution and fund agencies also present in the network indicates a well-supported target. Also, this network is strongly marked by the abundance of technical and data flow from herbaria, universities and research agencies to the main initiatives. Technical relationships appears here representing the Taxonomic Experts Network which supports the Flora of Brazil 2020 initiative, and the

Table 3 – Summary of network nodes, by GSPC target.

GSPC Targets	Related National Biodiversity Targets	Nº. of Actions	Node Category (agents)							Total of nodes (agents)		Nodes by actions ratio ¹
			Government	NGO	Private	Research and Education	Fund Agency	Project, Program or Initiative	Herbaria	Botanic Garden	Protected Area	
Target 1	Target 19	77	25	3	3	155	2	6	70	11		275 3,57
Target 2	Target 12	27	28	20	4	86	3	3	8	38	1	191 7,07
Target 3	Target 19	77	40	21	7	171	4	6	74	14	1	338 4,39
Target 4	Targets 5, 11 and 14	135	30	11		2	1	2				46 0,34
Target 5	Targets 5 and 11	116	28	11		2	1	2				44 0,38
Target 6	Targets 7 and 8	50	15	6		3						24 0,48
Target 7	Target 12	27	15	2		7		2		34		60 2,22
Target 8	Targets 12, 13 and 15	132	27	10		8		4	5	34		88 0,67
Target 9	Target 13	14	10	1		6		1		34		52 3,71
Target 10	Target 9	28	10	4		1		5				20 0,71
Target 11	Target 12	27	15	2		7		2		34		60 2,22
Target 12	Target 4	12	5	2		1						8 0,67
Target 13	Target 18	16	5	3		1				1		10 0,63
Target 14	Target 1	52	16	5	1	6				1		29 0,56

¹ The sum of the agents (institutions, projects, programs, initiatives, fund agencies, etc.) committed to the target achievement divided by the number of actions related to the target.

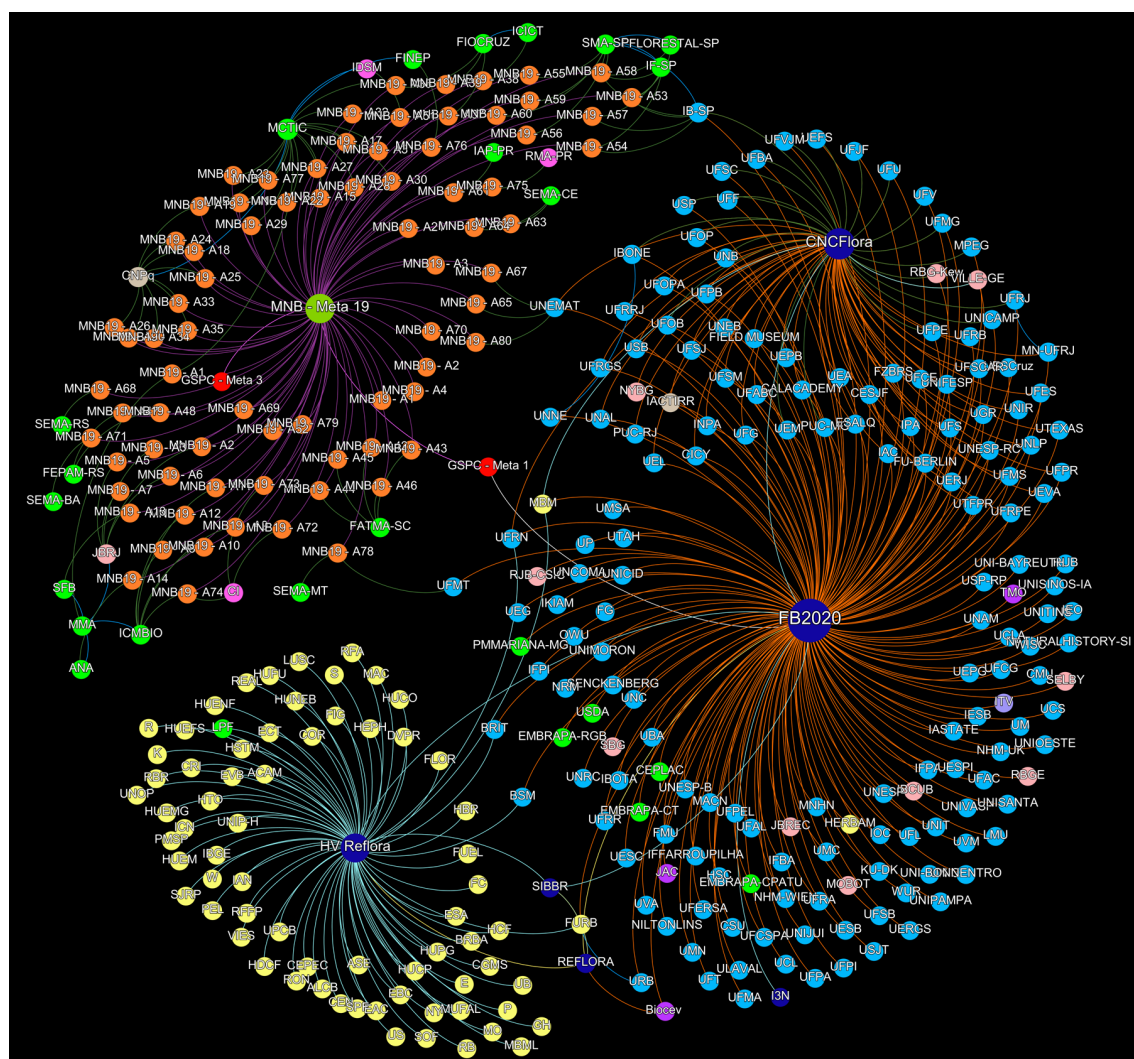


Figure 6 – Network visualization for GSPC Target 1.

Number of Institutions related with GSPC Target 1					
Univ. and Research	155	Botanic Garden	11	Funding Agencies	2
Herbarium	70	NGO	3	Initiatives	6
Government	25	Private	3		

Color legend for Nodes				
Actions		Botanic Garden		Initiative
Univ. and Research		NGO		Fund agency
Herbarium		GSPC Target		Private Inst.
Government		National Biodiv. Target		

Color legend for Edges			
Actions		Data	
Action-target		Funding	
Technical		Coordination	
Institutional		Target-Target	

data relationships linking the herbaria to the Reflora Virtual Herbarium (HV Reflora) which represent the digital voucher and associated data sent by those institutions to be part of this important initiative. Action towards the achievement of this target at the global scale is coordinated through the World Flora Online Consortium, a voluntary network of major botanical organizations and institutions worldwide, including Brazilian members (Wyse Jackson & Miller 2015).

This GSPC target, together with the GSPC target 3, has benefited from the Global Environment Facility (GEF) funds related to the project “Improving Brazilian Capacity to Conserve and Use Biodiversity through Information Management and Use” (Global Environment Facility 2018).

Target 2 - An assessment of the conservation status of all known plant species, as far as possible, to guide conservation action.

National Biodiversity Targets related: 12
Actions: 27

The GSPC Target 2 network visualization (Fig. 7) also shows an initiative dedicated to achieving this target, the National Center for Flora Conservation - CNCFlora. Sharing with the Flora of Brazil initiative the technical support of universities and research institutions, the network also shows a significant amount of technical and data flow.

The network also shows the relationship of CNCFlora, through its host institution, the Rio de Janeiro Botanical Garden, with the GSPC Target 8.

Target 3 - Information, research and associated outputs, and methods necessary to implement

the Strategy developed and shared
National Biodiversity Targets related: 19
Actions: 77

Again, the three main initiatives, which are strongly related each other - Flora of Brazil 2020, CNCFlora and REFLORA Virtual Herbarium, appear here (Fig. 8) as key actors, leveraging and sharing data and information related with plant conservation.

Consequently, the same level of technical and data relationship is present in this visualization. Different of the graph shown at Target 1, In this visualization, the Ministry of Science, Technology, innovation and Communication (MCTIC) appears with two additional funding agencies supporting some actions related with the National Biodiversity Target 19.

Target 3 is a very broad cross-cutting target that relates to many aspects of the research outputs, experience, tools, technologies and methodologies required for the achievement of the other targets of the GSPC. Therefore, it is expected that a wide range of organizations and sectors will be relevant and actively involved in the achievement of this target. The network visualization demonstrates this clearly but with a number of important research institutes and key initiatives very prominent.

Target 4 - At least 15 per cent of each ecological region or vegetation type secured through effective management and/or restoration.

National Biodiversity Targets related: 5, 11, 14
Actions: 135

This GSPC target is related to three National Biodiversity Targets, showing a great number of actions (135) but, in contrast, it shows just a few institutions committed to supporting these actions (46) (Fig. 9).

Despite the existence of a “mission” relationship between the GSPC Target 4 and the Chico Mendes Institute for Biodiversity Conservation, a Ministry of Environment Institute, we can note the absence of initiatives directly related with the target, bringing technical, data and infrastructure which would support the target achievement. Achievement of this target often relates to national level planning processes and actions related to the establishment, regulation, conservation and management of large areas of land, such as are included in the major protected areas of most countries (national parks and nature reserves). However, the achievement of this target also relates to conservation of land outside the protected area system and may be achieved too by incentives to protect plants in, for example, production landscapes. The government sector is therefore crucial in the delivery of this target. Any sector concerned about sustaining ecosystem services will be relevant to this target.

Target 5 - At least 75 per cent of the most important areas for plant diversity of each ecological region protected with effective management in place for conserving plants and their genetic diversity.

National Biodiversity Targets related: 5, 11
Actions: 116

The visualization of this GSPC Target 5 (Fig. 10) is very similar to the graph of the previous

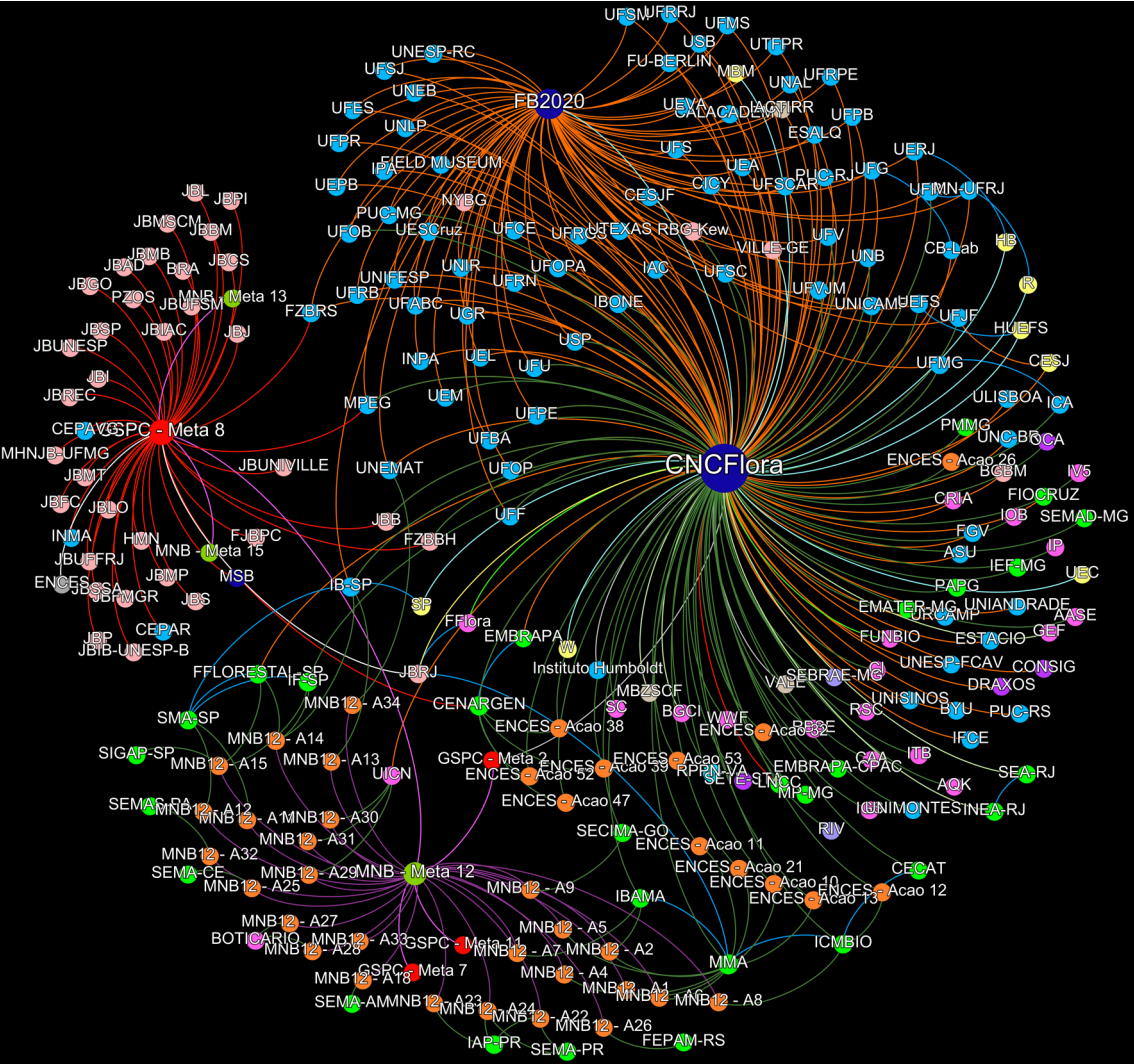


Figure 7 – Network visualization for GSPC Target 2.

Number of Institutions related with GSPC Target 2					
Univ. and Research	86	Botanic Garden	38	Funding Agencies	3
Herbarium	8	NGO	20	Initiatives	3
Government	28	Private	4	Protected Area	1

Color legend for Nodes				
Actions	Botanic Garden	Initiative		
Univ. and Research	NGO	Fund agency		
Herbarium	GSPC Target	Private Inst.		
Government	National Biodiv. Target	Protected Areas		

Color legend for Edges				
Actions	Data	Funding		
Action-target	Infrastructure	Coordination		
Technical	Management	Mission		
Institutional	Target-Target			

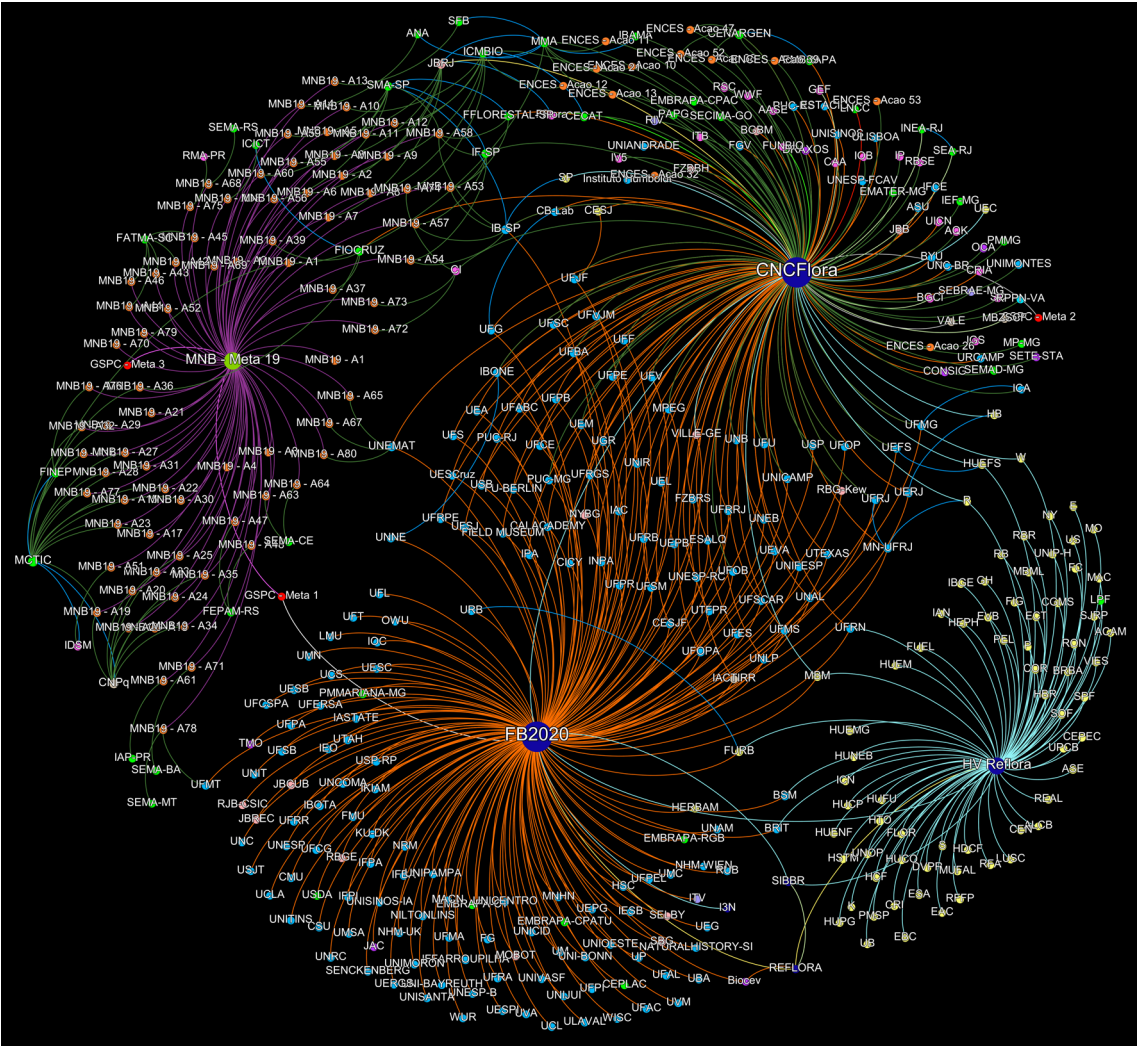


Figure 8 – Network visualization for GSPC Target 3.

Number of Institutions related with GSPC Target 3					
Univ. and Research	171	Botanic Garden	14	Funding Agencies	4
Herbarium	74	NGO	21	Initiatives	6
Government	40	Private	7	Protected Area	1

Color legend for Nodes				
Actions		Botanic Garden		Initiative
Univ. and Research		NGO		Fund agency
Herbarium		GSPC Target		Private Inst.
Government		National Biodiv. Target		Protected Areas

Color legend for Edges				
Actions		Data		Funding
Action-target		Infrastructure		Coordination
Technical		Management		Mission
Institutional		Target-Target		

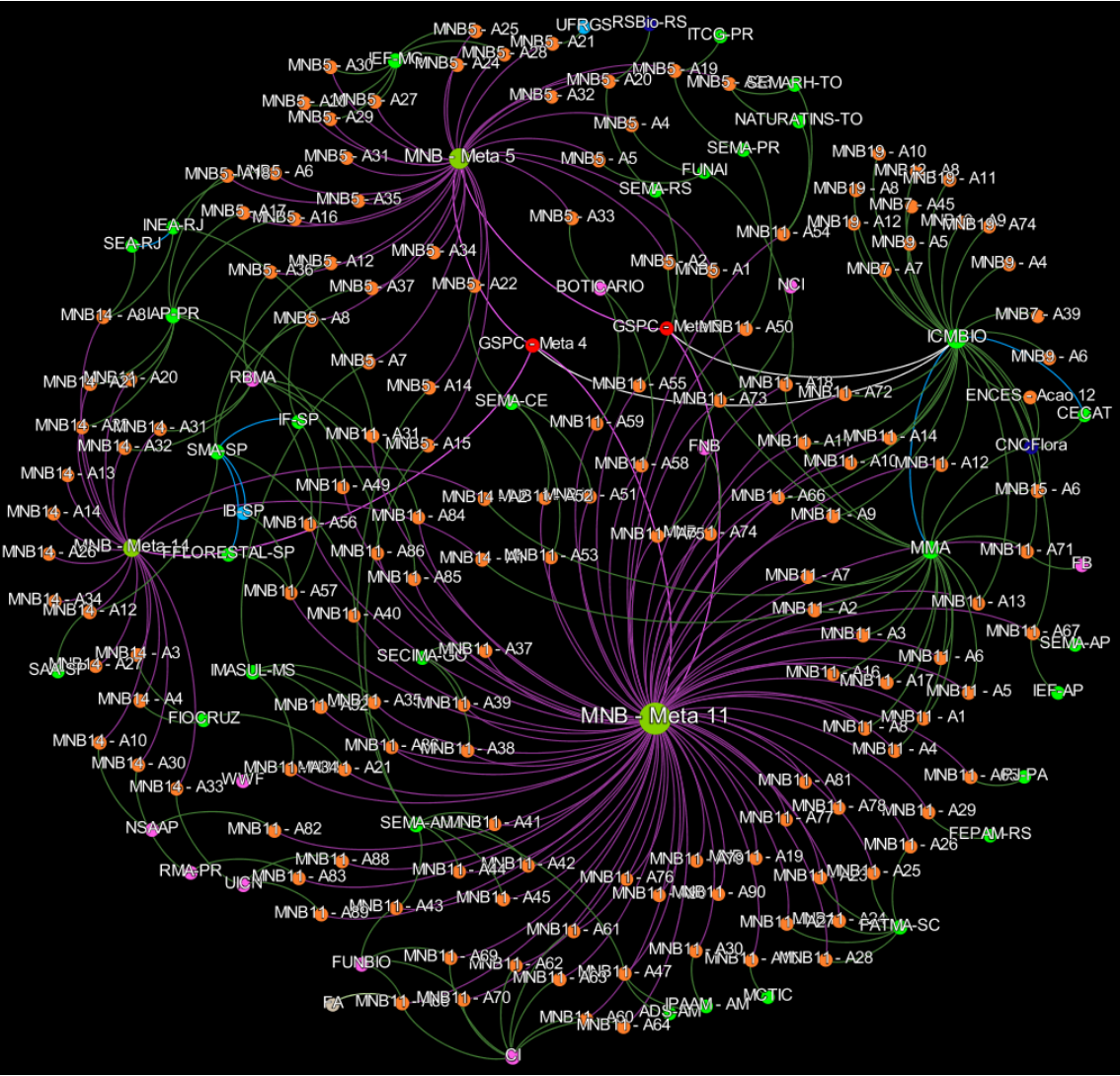


Figure 9 – Network visualization for GSPC Target 4.

Number of Institutions related with GSPC Target 4			
Univ. and Research	2	Funding Agencies	1
Government	30	Initiatives	2
NGO	11		

Color legend for Nodes			
Actions	Initiative		
Univ. and Research	NGO		
Fund agency	GSPC Target		
Government	National Biodiv. Target		

Color legend for Edges			
Actions	Mission	Funding	
Action-target	Target-Target	Institutional	

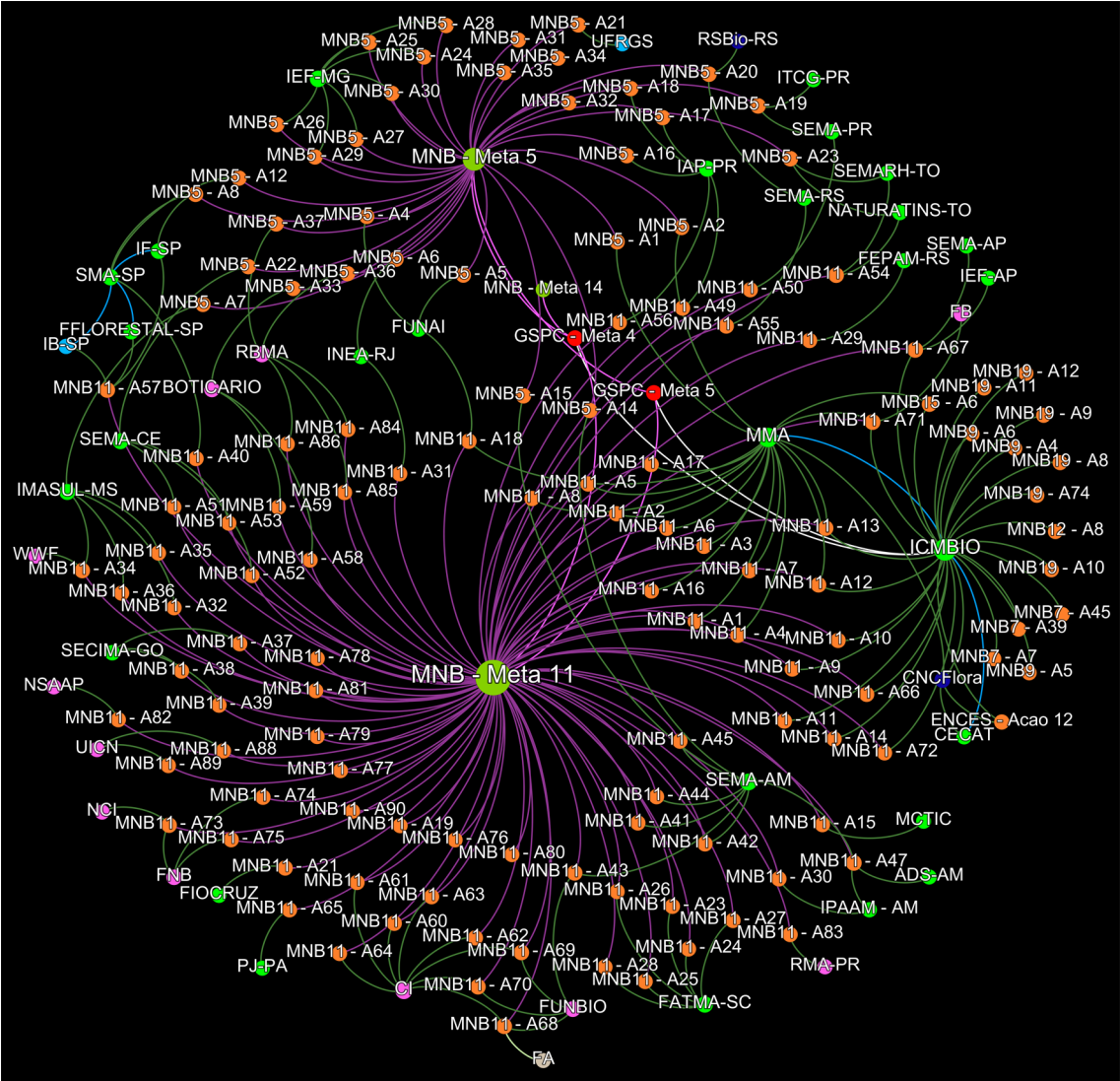


Figure 10 – Network visualization for GSPC Target 5.

Number of Institutions related with GSPC Target 5			
Univ. and Research	2	Funding Agencies	1
Government	28	Initiatives	2
NGO	11		

Color legend for Nodes			
Actions		Initiative	
Univ. and Research		NGO	
GSPC Target		Fund agency	
Government		National Biodiv. Target	

Color legend for Edges			
Actions		Target-Target	
Action-target		Funding	
Institutional		Mission	

GSPC Target. This similarity is because both GSPC targets are related to the National Biodiversity Targets 5 and 11. However, different from the GSPC Target 4, this GSPC target is not associated with the National Biodiversity Target 14.

Again, we may note a large number of actions related to the NBT 5 and 11 associated with the lack of proportional support of institutions and initiatives. The achievement of Target 5 relies both on the identification of the most important areas for plant diversity as well as their effective management, to achieve the conservation of the plant species they contain. These two separate components can need actions undertaken by agencies and institutions in different sectors. Enhanced collaboration across sectors to achieve this target is clearly necessary.

Target 6 - At least 75 per cent of production lands in each sector managed sustainably, consistent with the conservation of plant diversity
National Biodiversity Targets related: 7, 8
Actions: 50

The GSPC Target 6 generated a graph with just 74 nodes, representing 50 actions and 24 agents committed to those actions (Fig. 11). There is no initiative or funding agency related to this target and its counterparts at the National Biodiversity Targets: NBT 7 and 8. Monitoring the achievement of this target is often problematic since the primary responsibility for this target generally falls beyond the remit of the biodiversity sector and involves the agricultural and forestry agencies and sector. Government actions in relation to this target include regulation and incentives to promote sustainable actions and areas such as organic production and sustainable forest management.

Target 7 - At least 75 per cent of known threatened plant species conserved in situ
National Biodiversity Targets related: 12
Actions: 27

The GSPC Target 7 network visualization brings only 27 actions, from NBT 12, spread through 60 agents related to these actions (Fig. 12). As NBT 12 is related to four GSPC Targets (2, 7, 8 and 11), we can note that botanic gardens providing infrastructure to the GSPC Target 8 is an important part of the graph. Actions to achieve this target are very diverse, involving research, inventories and monitoring

of wild plant populations, conservation status assessments, management of species, habitats and whole ecosystems, rescue and recovery of individual threatened species and ecological restoration. The achievement of this target therefore requires active cross-sectoral networking. The network visualization for this target indicates only modest levels of such cooperation and collaboration currently.

Target 8 - At least 75 per cent of threatened plant species in ex situ collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes
National Biodiversity Targets related: 12, 13, 15
Actions: 132

The network visualization of the GSPC Target 8 (Fig. 13), together with actions that came from the National Biodiversity Strategies and Action Plans (NBSAPs), shows a specific set of actions that came from the National Strategy for Ex Situ Conservation of Threatened Species from the Brazilian's Flora (CNCFLORA 2016). In the graph, we can also see the important role of the National Center of Genetic Resources (CENARGEN) to address those actions.

Related to the GSPC Target 8, we also found the potential and important role of the Brazilian's Botanic Gardens Network, providing infrastructure to achieve the target. It is not clear from the network visualization to what extent the actions taken in the achievement of this target relate both to ex situ conservation (cultivation of living collections and seed storage) and recovery and restoration programmes. The latter actions often require collaboration with non-garden organizations, including research institutions and land-managing agencies, linking to the achievement of target 7.

Target 9 - 70 per cent of the genetic diversity of crops including their wild relatives and other socio-economically valuable plant species conserved, while respecting, preserving and maintaining associated indigenous and local knowledge
National Biodiversity Targets related: 13
Actions: 14

In this graph (Fig. 14), we see only 14 actions which came from the related National Biodiversity

Target 13. The number of botanic gardens that appears in the graph are related to the GSPC Target 8. Thus, there are only 12 agents directly involved in the 14 actions proposed at the NBSAPs. Conservation of major crop diversity has been, by and large, a responsibility of the government

sector in Brazil. Botanic garden involvement has been mainly limited to the conservation (cultivation and seed storage primarily) of wild plants that are either crop wild relatives or of other socio-economic importance (such as medicinal plants and timber trees).

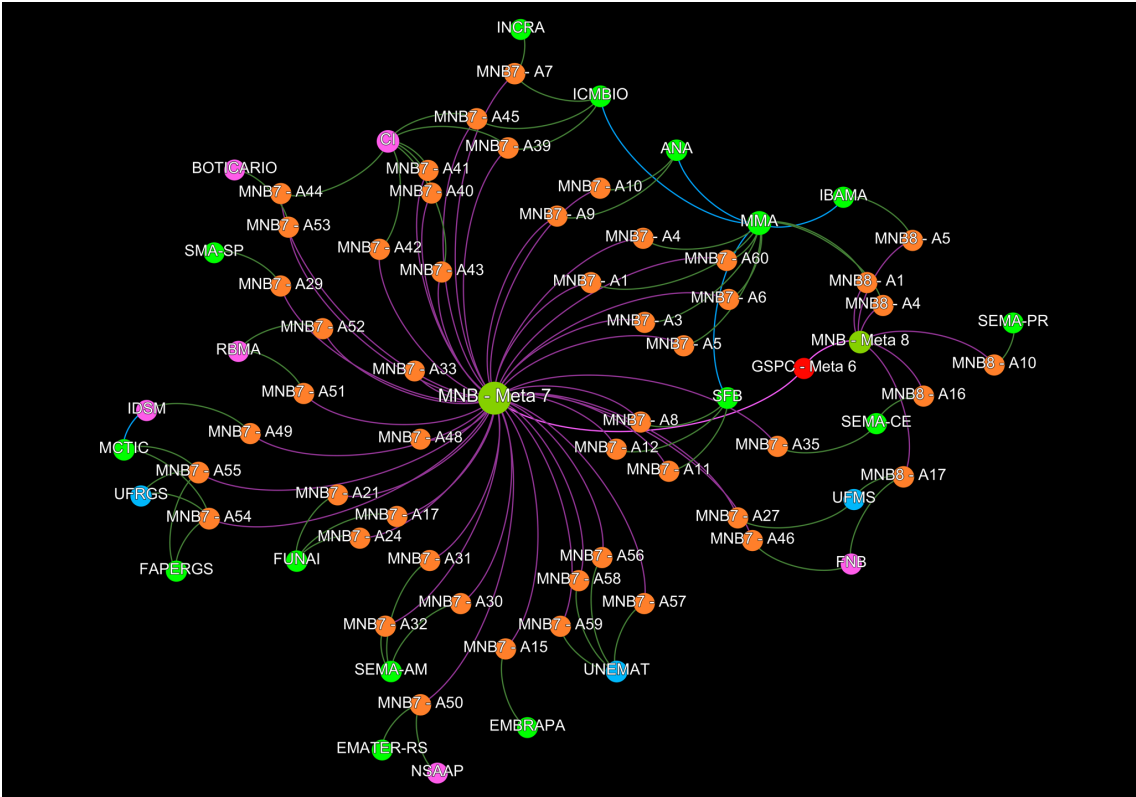


Figure 11 – Network visualization for GSPC Target 6.

Number of Institutions related with GSPC Target 6	
Univ. and Research	3
Government	15
NGO	6

Color legend for Nodes			
Actions			
Univ. and Research		NGO	
		GSPC Target	
Government		National Biodiv. Target	

Color legend for Edges			
Actions		Institutional	
Action-target		Target-Target	

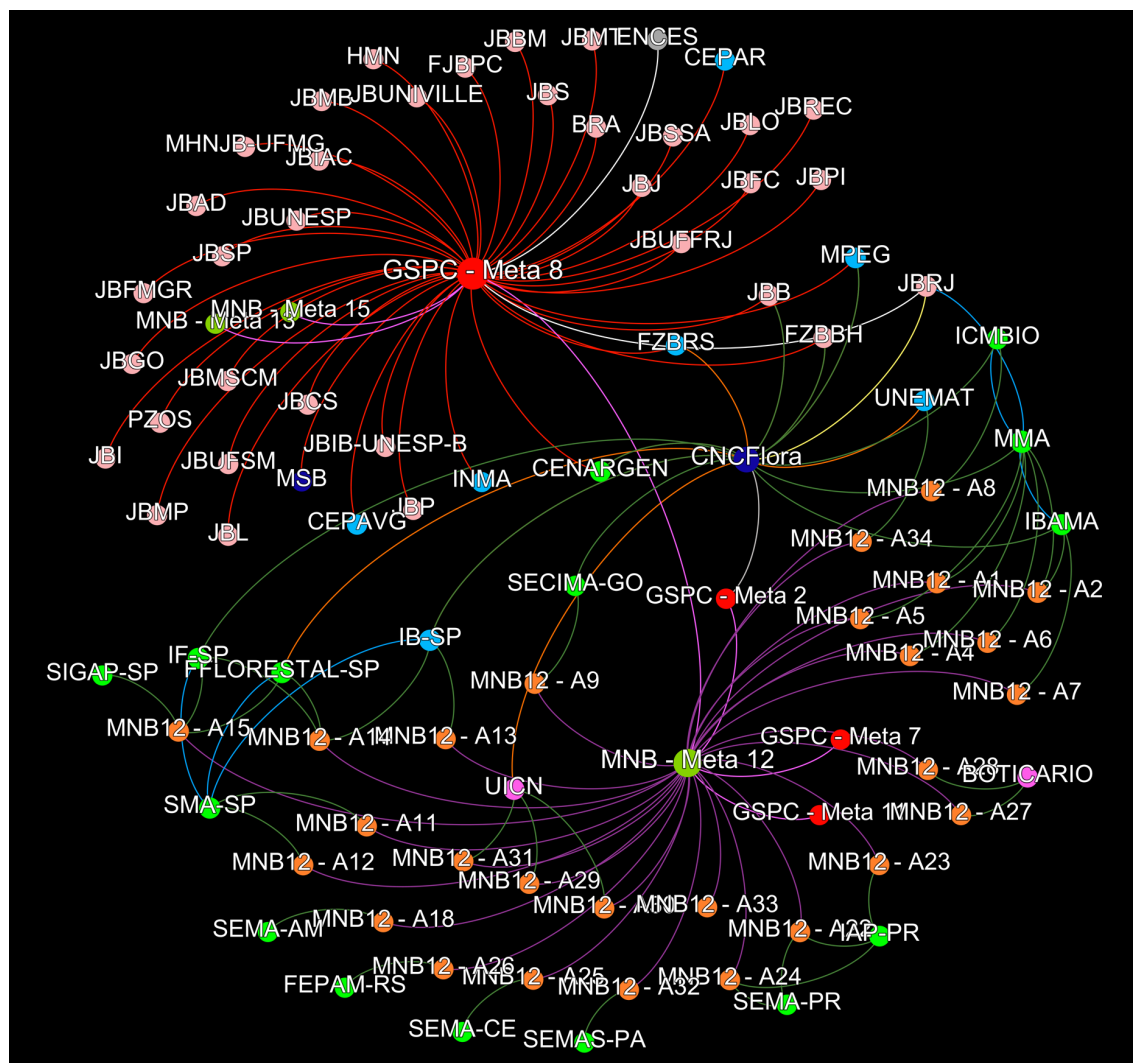


Figure 12 – Network visualization for GSPC Target 7.

Number of Institutions related with GSPC Target 7			
Univ. and Research	7	NGO	2
Government	15	Initiatives	2
Botanic Garden	34		

Color legend for Nodes			
Actions		Botanic Garden	
Univ. and Research		NGO	
Initiative		GSPC Target	
Government		National Biodiv. Target	

Color legend for Edges			
Actions		Coordination	
Action-target		Infrastructure	
Technical		Mission	
Institutional		Target-Target	

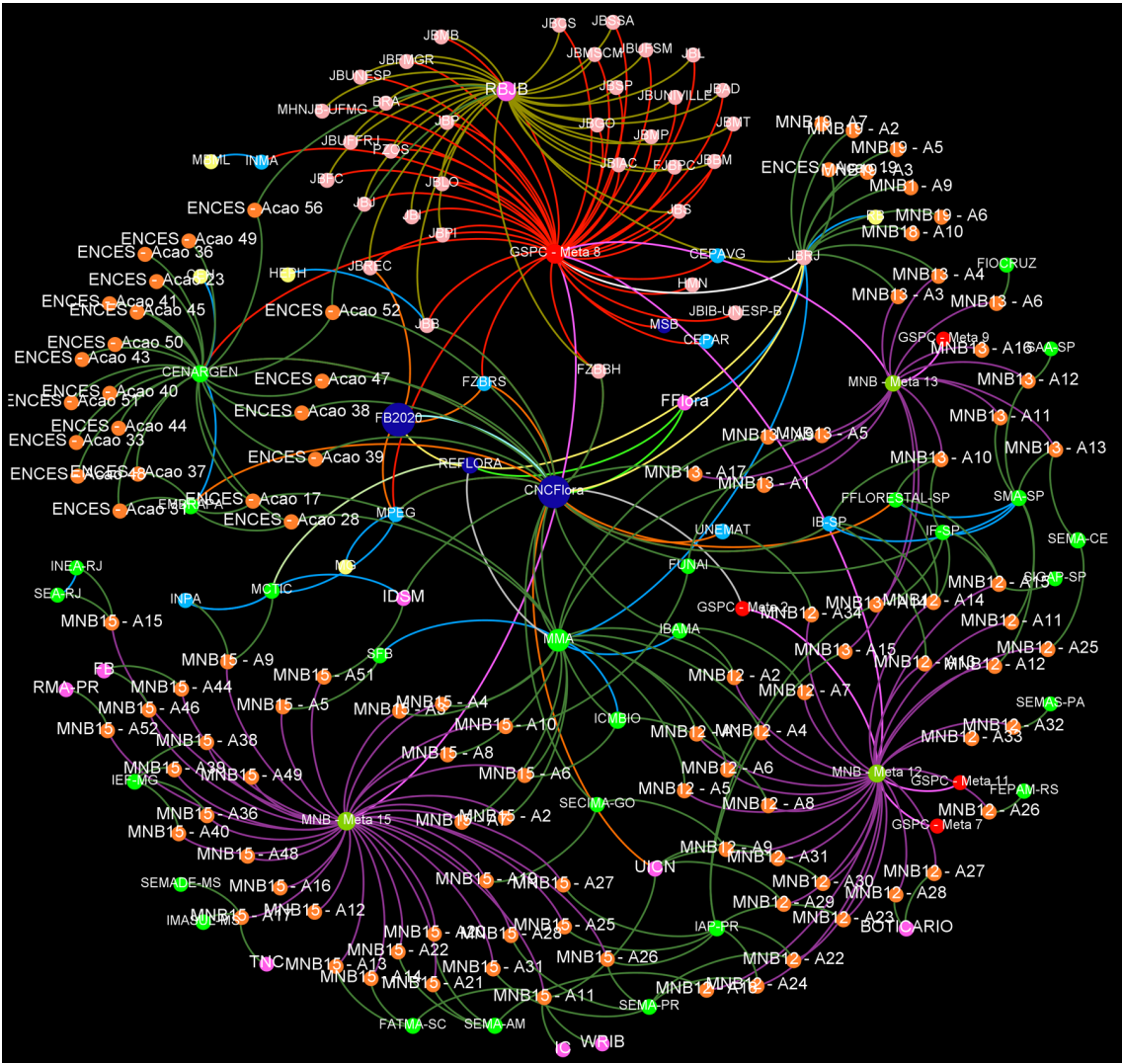


Figure 13 – Network visualization for GSPC Target 8.

Number of Institutions - related with GSPC Target 8			
Univ. and Research	8	Botanic Garden	34
Herbarium	5	NGO	10
Government	27	Initiatives	4

Color legend for Nodes			
Actions	Botanic Garden	Initiative	
Univ. and Research	NGO		
Herbarium	GSPC Target		
Government	National Biodiv. Target		

Color legend for Edges			
Actions	Data	Funding	
Action-target	Infrastructure	Coordination	
Technical	Network	Mission	
Institutional	Target-Target	Management	

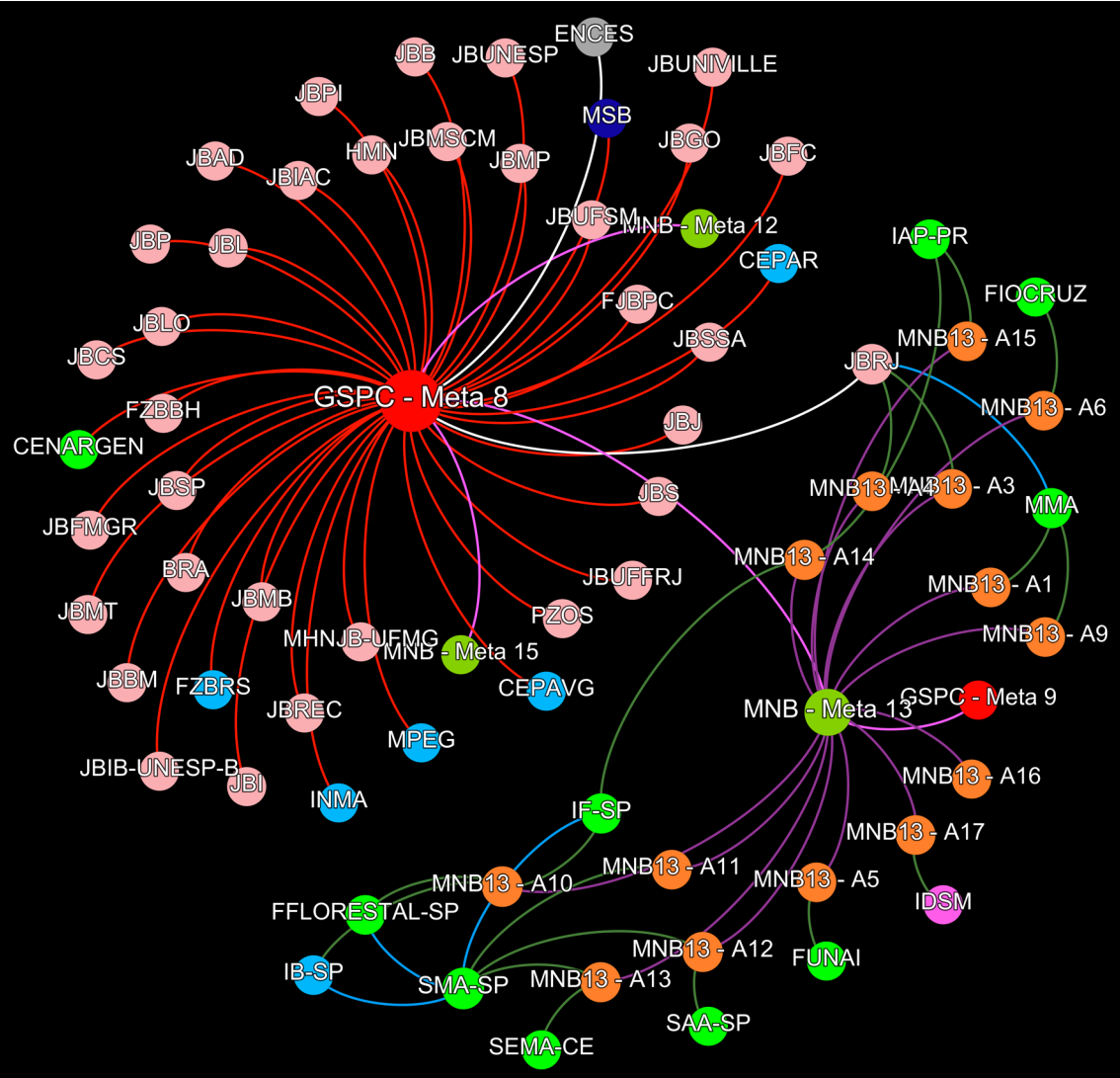


Figure 14 – Network visualization for GSPC Target 9.

Number of Institutions related with GSPC Target 9			
Univ. and Research	6	NGO	1
Government	10	Initiatives	1
Botanic Garden	34		

Color legend for Nodes			
Actions	Orange	Botanic Garden	Pink
Univ. and Research	Blue	NGO	Pink
Initiative	Green	GSPC Target	Red
Government	Green	National Biodiv. Target	Green

Color legend for Edges			
Actions	Green	Target-Target	Pink
Action-target	Green	Infrastructure	Red
Institutional	Blue	Mission	

Target 10 - Effective management plans in place to prevent new biological invasions and to manage important areas for plant diversity that are invaded
National Biodiversity Targets related: 9

Actions: 24

For this GSPC target, we can see an NGO, the “Horus Institute” that is coordinating four initiatives directed to the theme of invasive species (Fig. 15). Without Research and Education institutions involved, the GSPC Target 10 has only government and non-governmental institutions involved. The limited actions up to now mainly relate to identification, listing and monitoring of actual or potentially damaging invasive species and other biological invasions (such as pests and diseases that impact wild and crop plants).

Target 11 - No species of wild flora endangered by international trade
National Biodiversity Targets related: 12

Actions: 27

The GSPC Target 11 is only related to the NBT 12, which brings to the graph the network of botanic gardens related to the GSPC Target 8, as well as all the actions and agents related to them (Fig. 16). This characteristic makes this graph and numbers virtually identical to that of the GSPC Target 7. This target directly relates to international trade and includes the protection of a wide variety of Brazilian plant species. Particularly notable is *Dalbergia nigra*, a threatened species with highly prized and valuable timber. This species was listed for protection by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1992. All the species of some plant families such as the Orchidaceae and Cactaceae are included in CITES (Appendix 2, including species where trade must be controlled). Botanic gardens are major contributors to the achievement of this target, both through their action in cultivating and conserving CITES listed species as well as acting as rescue centers for species seized when international trade regulations are breached. Implementation of CITES at the national level is a government responsibility.

Target 12 - All wild harvested plant-based products sourced sustainably
National Biodiversity Targets related: 4
Actions: 12

The GSPC Target 12 is the simplest graph of all the GSPC Targets, with only 12 actions and 8 agents

related to these actions (Fig. 17). The simplicity of this graph probably relates, at least in part, to a lack of knowledge about the degree to which many plant-based products are currently being sourced sustainably, used for food, medicine, timber and other purposes. Nevertheless, it is probably the case that this target is also amongst those where the least progress has been made in its achievement.

Target 13 - Indigenous and local knowledge innovations and practices associated with plant resources maintained or increased, as appropriate, to support customary use, sustainable livelihoods, local food security and health care
National Biodiversity Targets related: 18
Actions: 16

In the same way as the previous visualization, the GSPC Target 13 presents a simple graph (Fig. 18), with 16 actions related to their counterpart in the NBSAPs – the National Biodiversity Target 18. Compared to the delivery of some other targets, target 13 has a relatively small number of organizations and institutions contributing to its achievement. Nevertheless, indigenous and local knowledge about plants and their use, often collectively referred to as “traditional knowledge”, is widely held by a diversity of national and local communities and groups in Brazil, many of which are beyond the scope to the current network visualization. Therefore the achievement of this target and conservation actions related to it is broader than that for many other GSPC targets.

Target 14 - The importance of plant diversity and the need for its conservation incorporated into communication, education and public awareness programs
National Biodiversity Targets related: 1
Actions: 52

The GSPC Target 14 is directly related to the National Biodiversity Target 1, which brings 52 actions and 29 agents committed with those actions. The Network visualization (Fig. 19) suggests that a wide diversity of organizations and institutions in various sectors are contributing significantly towards the achievement of this target, both independently and in collaboration with others across sectors.

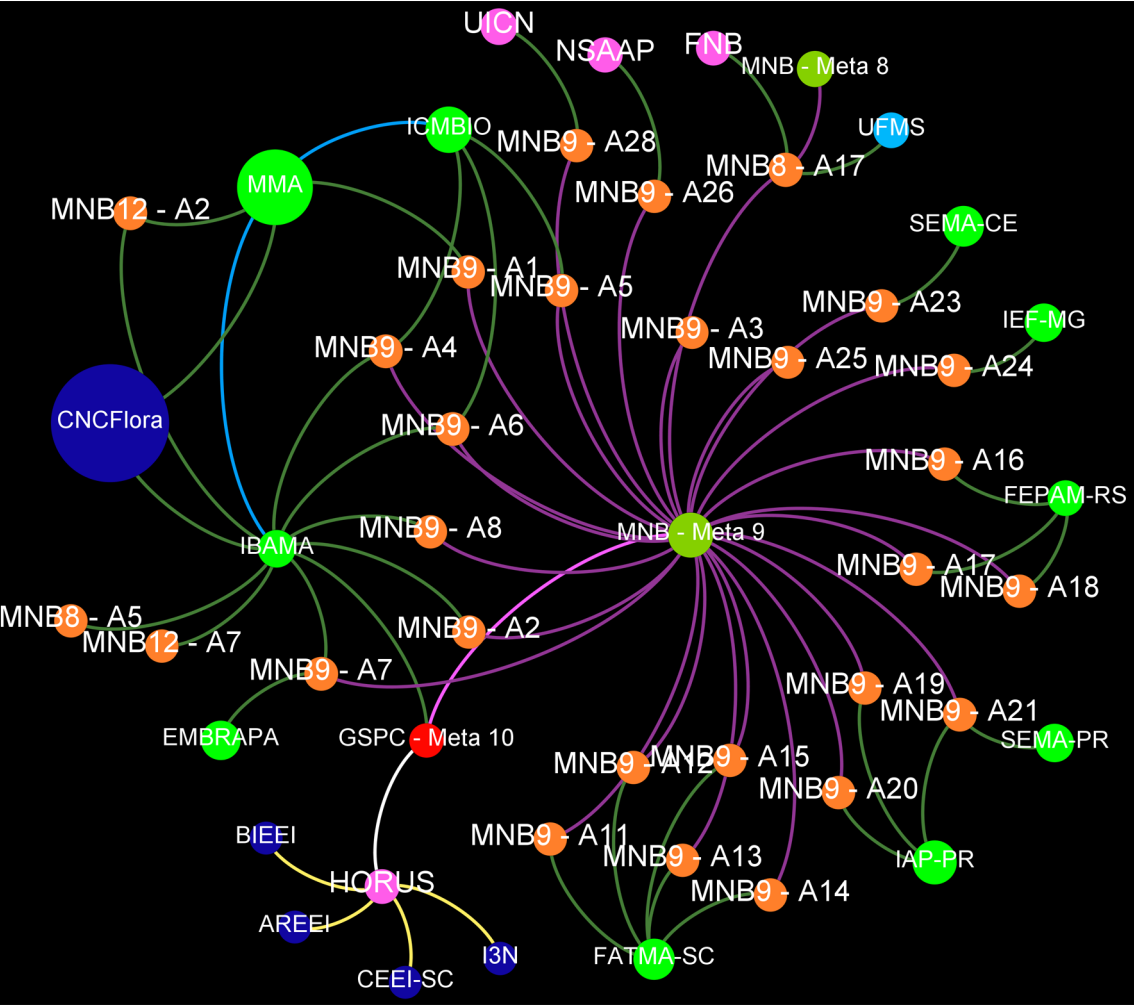


Figure 15 – Network visualization for GSPC Target 10.

Number of Institutions related with GSPC Target 10	
Government	10
NGO	4
Initiatives	5
Univ. and Research	1

Color legend for Nodes		
Actions		National Biodiv. Target
Univ. and Research		NGO
Initiative		GSPC Target
Government		

Color legend for Edges		
Actions		Target-Target
Action-target		Coordination
Institutional		Mission



Color legend for Nodes			
Actions		Botanic Garden	
Univ. and Research		NGO	
Initiative		GSPC Target	
Government		National Biodiv. Target	

Rodriguésia 69(4): 1613-1639. 2018

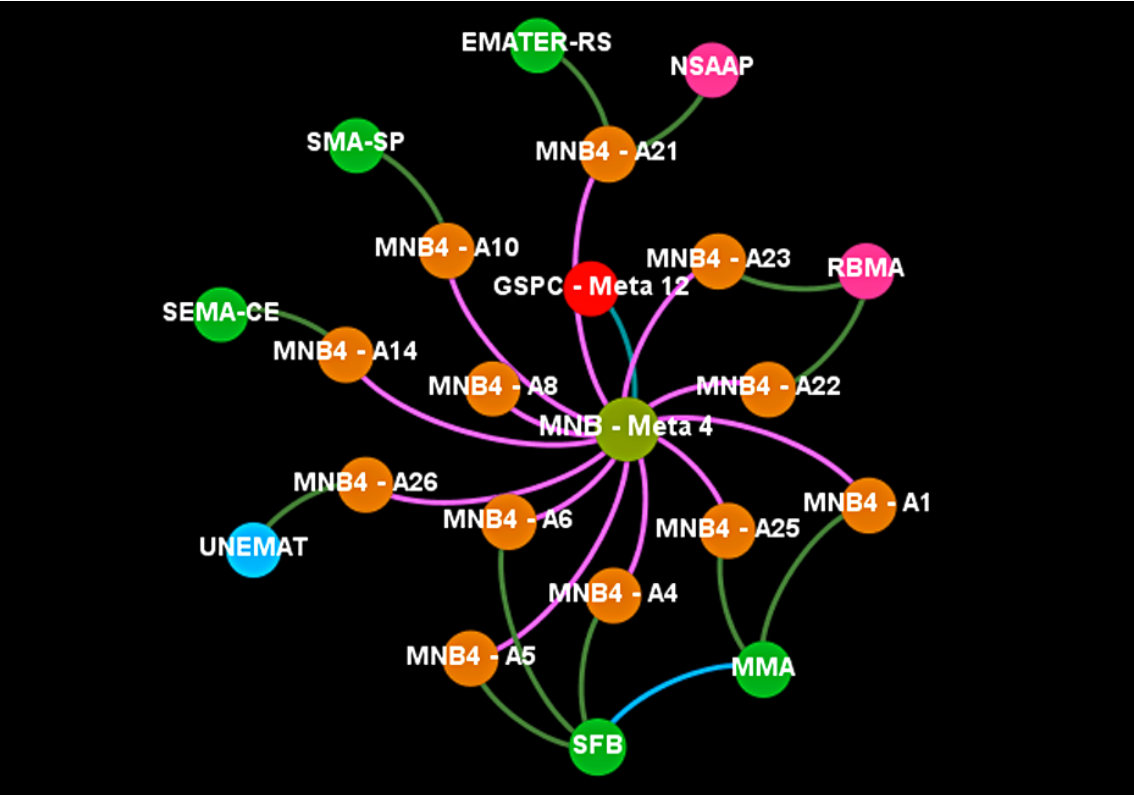


Figure 17 – Network visualization for GSPC Target 12.

Number of Institutions related with GSPC Target 12	
Univ. and Research	1
Government	5
NGO	2

Color legend for Nodes		
Actions		National Biodiv. Target
Univ. and Research		NGO
Government		GSPC Target

Color legend for Edges		
Actions		Institutional
Action-target		Target-Target

The Network

The vision of the entire network (Figs. 20, 21) highlights the considerable number of actions (786), when comparing with the number of institutions committed to delivering those actions (435).

The number of initiatives is not evenly spread over the graph, emphasizing the lack of initiatives related to most of the actions.

In this visualization of the entire network, we can see limited and concentered relationships

that representing flows of data, technical support and infrastructure.

Discussion

Brazil has no formal specific instrument oriented towards the achievement of the GSPC targets. Its implementation, monitoring and reporting is vested in those national authorities concerned with the achievement of the objectives of the Convention on Biological Diversity. However,

as shown in the visualizations of the GSPC Targets 1, 2 and 3, there are strong initiatives in place dedicated to the achievement of those targets throughout a wide range of diverse sectors. We can see this at the level of the visualizations by the significant, or even the simple existence, of institutions providing data, technical support, and infrastructure to those initiatives. In many cases, the involvement of particular institutions and organizations in actions related to the achievement

of particular targets may be voluntary, and in some cases, these actions are not necessarily recognized by those organizations as contributing to the GSPC.

There is a general lack of documents, reports and academic articles that support the monitoring and assessment of the achievement of the GSPC 2020 Targets. However, the data suggest the existence of a very significant and diverse network of agents capable of supporting the actions related, directly or indirectly, to the GSPC Goals.

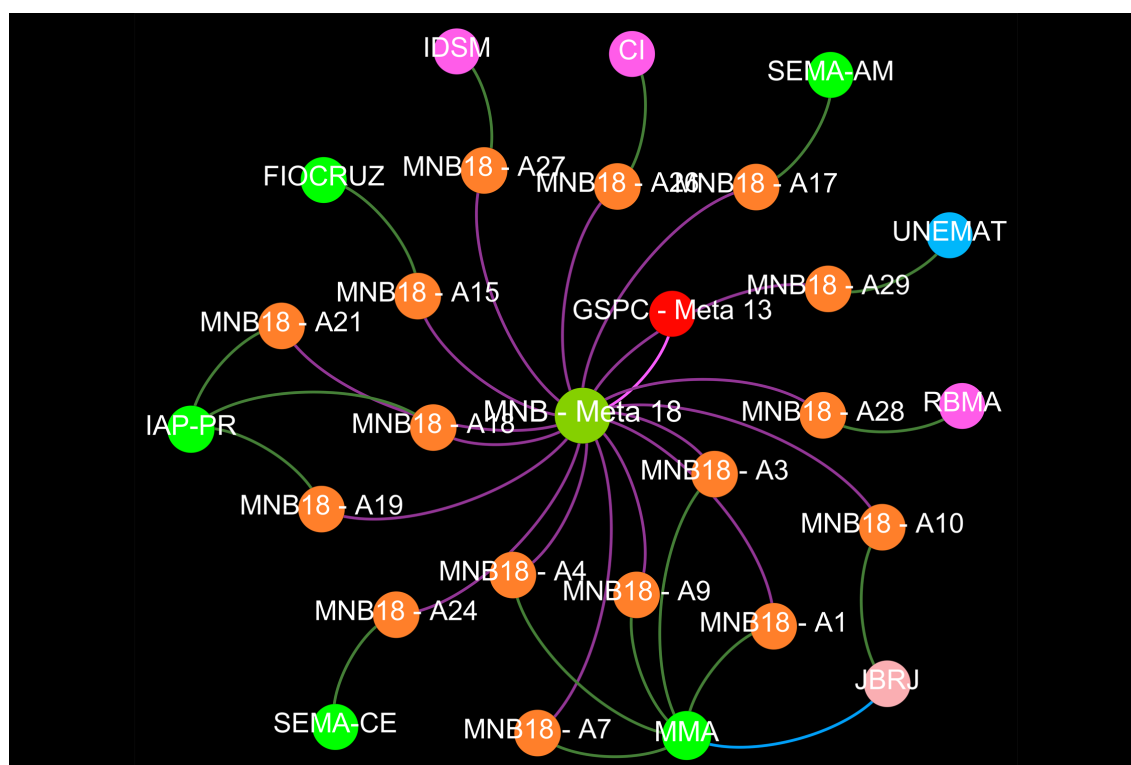


Figure 18 – Network visualization for GSPC Target 13.

Number of Institutions related with GSPC Target 13			
Univ. and Research	1	NGO	3
Government	5	Botanic Garden	1

Color legend for Nodes			
Actions	Orange	Botanic Garden	Pink
Univ. and Research	Blue	NGO	Pink
GSPC Target	Red	National Biodiv. Target	Green
Government	Green		

Color legend for Edges			
Actions	Green	Institutional	Blue
Action-target	Purple	Target-Target	Pink

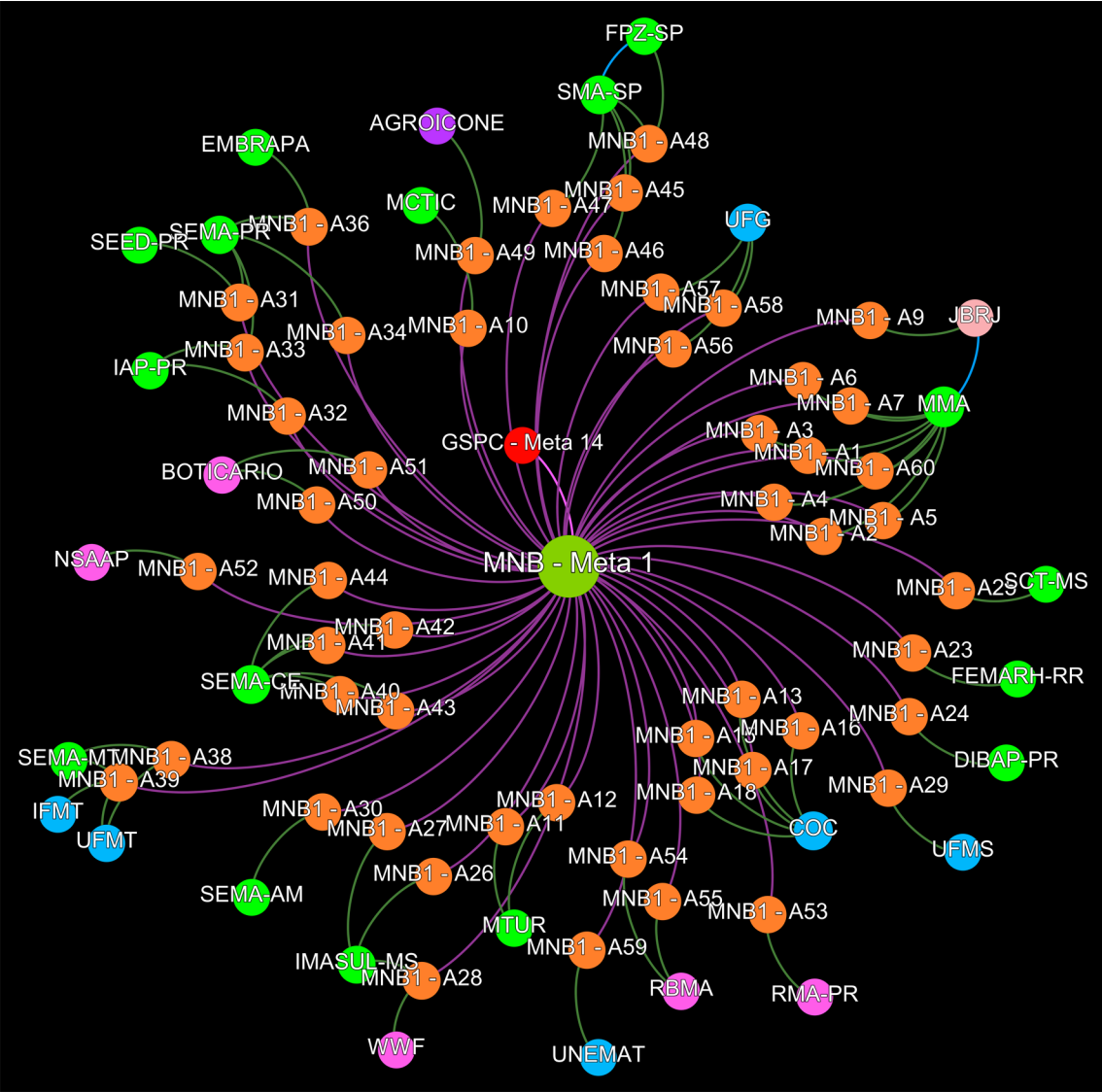


Figure 19 – Network visualization for GSPC Target 14.

Number of Institutions related with GSPC Target 14			
Univ. and Research	6	NGO	5
Government	16	Private	1
Botanic Garden	1		

Color legend for Nodes			
Actions		Botanic Garden	
Univ. and Research		NGO	
Private Inst.		GSPC Target	
Government		National Biodiv. Target	

Color legend for Edges			
Actions		Institutional	
Action-target		Target-Target	

The network seems to exist in two states: the effective and the potential. The effective state of the network has nodes and relationships that corroborate its effectiveness, such as coordination, mission, management and financial relations, data flow and technical support, as well as initiatives and funding nodes.

Coordination, funding, initiatives, resources, infrastructure, data and technical support suggest an effective state.

The effective state of the network suggests that the goals present in this network will be achieved.

We hope that the organizations, institutions

and agencies involved in GSPC implementation in Brazil will find these network visualizations helpful to assist in identifying gaps, opportunities for new actions and areas where network linkages may be extended, helping to move from “the potential” to “the effective”.

In this work, we have shown that the Network Visualization - a knowledge area which interacts with Data Visualization and Social Network Analysis areas - may be a useful tool to understand how efforts and institutional commitments are spread over a wide range of international environmental agreements and instruments, such as the GSPC.

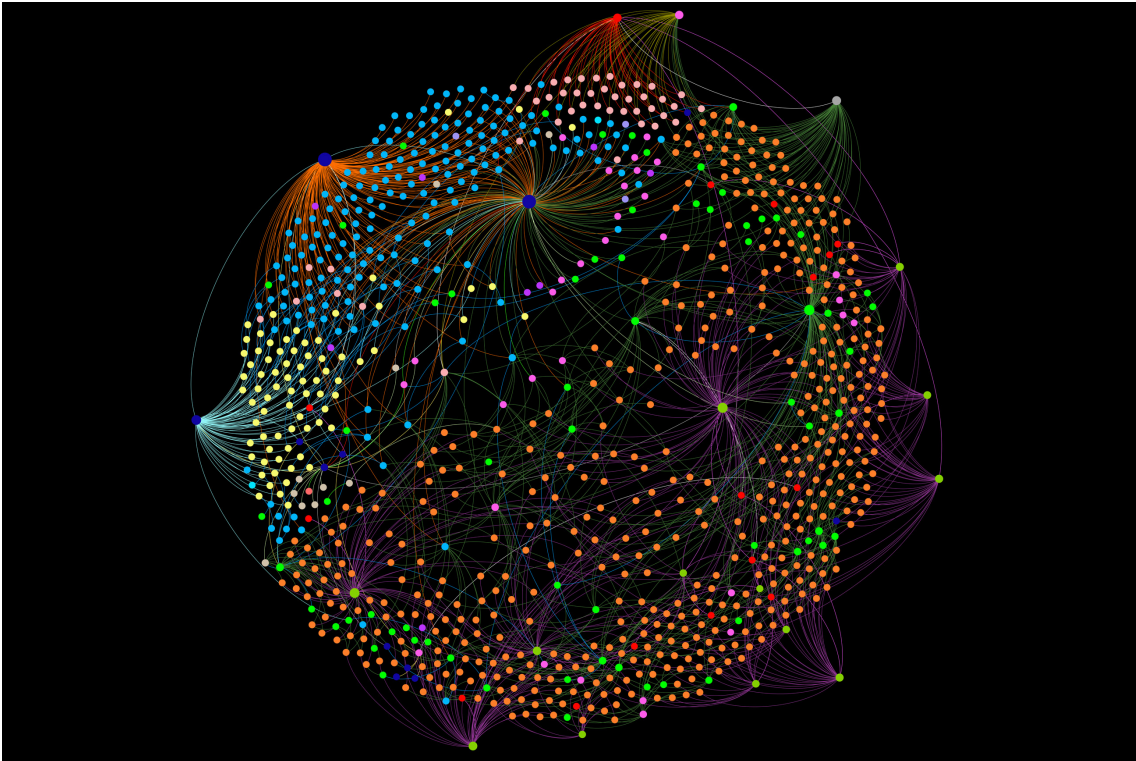


Figure 20 – Network visualization for GSPC.

Color legend for Nodes					
Actions		Botanic Garden		Initiative	
Univ. and Research		NGO		Fund agency	
Herbarium		GSPC Target		Private Inst.	
Government		National Biodiv. Target		Protected Areas	

Color legend for Edges			
Actions		Data	
Action-target		Infrastructure	
Technical		Network	
Institutional		Target-Target	

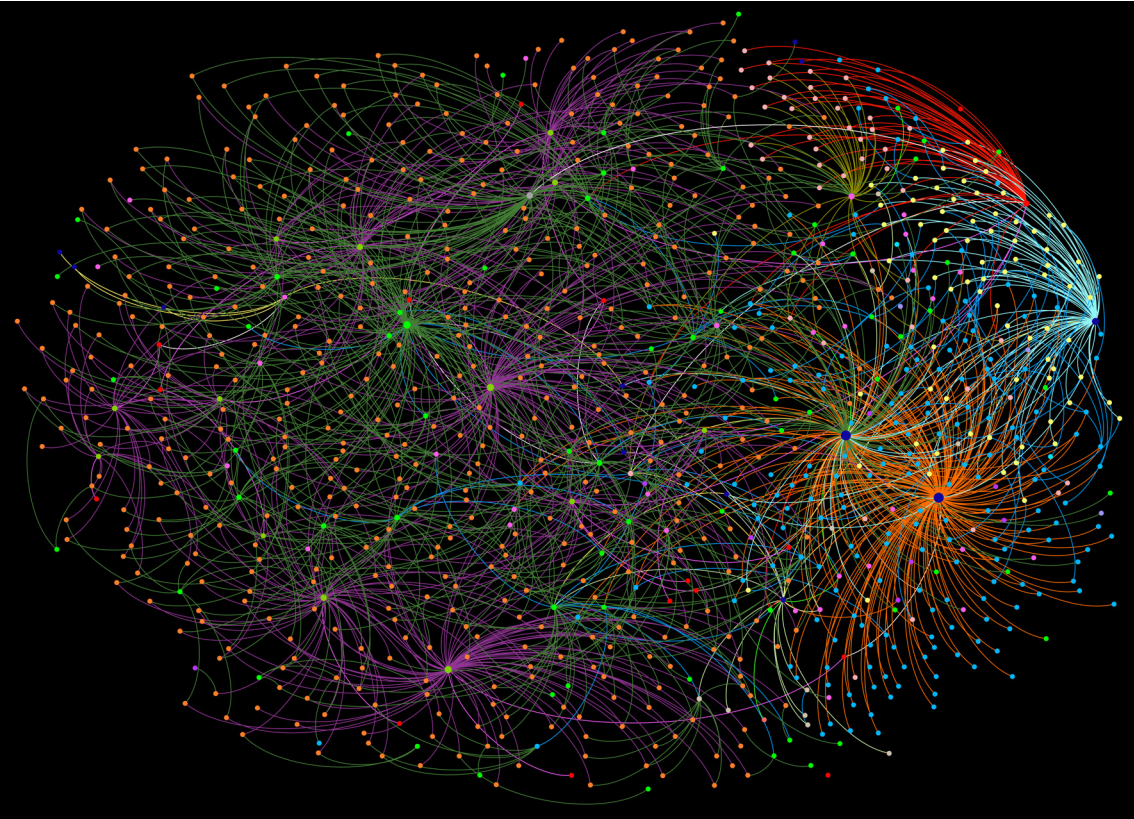


Figure 21 – Network visualization for GSPC.

Color legend for Nodes					
Actions	Botanic Garden	Initiative	Agency		
Univ. and Research	NGO	Fund agency			
Herbarium	GSPC Target	Private Inst.			
Government	National Biodiv. Target	Protected Areas			

Color legend for Edges			
Actions	Data	Funding	
Action-target	Infrastructure	Coordination	
Technical	Network	Mission	
Institutional	Target-Target	Management	

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