From: Shoemaker, Justin
To: Guinotte, John
Subject: Wolverine RD briefing memo
Date: Wednesday, June 7, 2017 3:48:46 PM
Attachments: Briefing Memo for RD_Wolverine SSA update.docx

First draft.

Justin Shoemaker
Classification Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

BRIEFING MEMORANDUM FOR THE REGIONAL DIRECTOR

DATE: June 7, 2017

FROM: Michael Thabault, Assistant Regional Director, Ecological Services

SUBJECT: Wolverine Species Status Assessment Update

To inform the Regional Director of the progress made on the wolverine Species Status Assessment (SSA) and the key information that will be of interest to the eventual wolverine listing decision. Briefing scheduled for June 15.

BACKGROUND

In compliance with a Court order that remanded our previous withdrawal of a proposed rule to list the contiguous U.S. Distinct Population Segment (DPS) of the wolverine (79 FR 47522; August 13, 2014), we will prepare either a revised proposed rule to list or a revised withdrawal of the previous proposed rule (78 FR 7864; February 4, 2013). In October 2016, we published a notice to announce the vacature of the withdrawal rule to the public, announce the proposed status since the judge's ruling, and to reopen the public comment period on the February 4, 2013 proposed rule to list the wolverine as a threatened species.

DISCUSSION

Highlighted in Judge Christensen's Court order remanding the withdrawal were the Service's determinations regarding: (a) the threat posed to the wolverine by the effects of climate change at the reproductive denning scale, (b) the threat posed to the wolverine by small population size and lack of genetic diversity, and (c) application of the SPR Policy to the wolverine. In our SSA we are making every effort to inform these points and ensure we are using the most up-to-date science upon which to base our listing decision.

Range of the species – our current approach to delineating wolverine range in the lower 48 is different, and we believe more accurate, than the broader range considered in the 2014 withdrawal.

Trapping Data – we have gathered additional trapping data not available to us in 2014 to inform the range of the species and the effect of trapping in Canada as it relates to an updated DPS determination.

NOAA/CU snow model – John?

New denning information – we have several records that were not available to us in 2014 of den sites found outside of modeled snow habitat in North America, as well as confirmation of successful wolverine dens outside of snow in Scandinavia.

PVA underway – we are coordinating with USGS on a PVA to inform minimum viable population size and the effects of demographic and habitat parameters on the wolverine population in the lower 48 States.

Genetics – see attached options paper.

NEXT STEPS

We plan to have the final SSA report, with peer and partner review incorporated, to the RD and decision team by December 2017.

ATTACHMENTS

Wolverine SSA and listing decision schedule attached.

Genetics options paper.

Commented [SJ1]: We can revise the paper we put together for Mike w/ actual $ amounts.

From:	Shoemaker, Justin
To:	Nelson, Marjorie
Cc:	Craig Hansen
Subject:	Re: Fisher and wolverine stuff
Date:	Thursday, June 8, 2017 7:58:27 AM

Waiting for Steve to look into genetics costs. I'll be working on a genetics option paper to go along w/ the RD briefing memo, and a SSA/listing schedule.

Justin Shoemaker
Classification Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

On Wed, Jun 7, 2017 at 4:44 PM, Nelson, Marjorie <marjorie_nelson@fws.gov> wrote:

> Thanks Justin,
> I think it would be okay for Kit to be there instead of Rollie, it is up to R1 who they send. Let's see how WTPD goes and approach it then (Mike is supposed to be at WTPD).
>
> Invite Nicole when Mike's out of town
>
> Wolverine - I'll keep an eye out for the BP. Do we have a genetics option paper that Mike asked for?
>
> thanks!
> Marj
>
> Marjorie Nelson
> Chief, Division of Ecological Services
> Mountain-Prairie Region
> U.S. Fish and Wildlife Service
> DIFFERENT NUMBER UNTIL 6TH FLOOR FIXED
> 720-582-3524
>
> On Wed, Jun 7, 2017 at 3:34 PM, Shoemaker, Justin <justin_shoemaker@fws.gov> wrote:
>
>> Marj,
>>
>> Fisher:
>>
>> I'm assuming we will be using a similar process to WTPD for fisher. So, I'm scheduling (or trying to anyway) a pre-RTM meeting w/ the ARD's for sometime July 5-7 (hoping to get 2 hrs at least). The actual RTM is scheduled for July 12.
>>
>> Questions:
>>
>> - Rollie cannot attend the RTM, but can attend the pre-RTM. Are we, or is our ARD/RD, ok with Kit filling in as the decision maker at the RTM? We asked the ULT at the meeting in CA, nobody had issue w/ the concept.
>>
>> - I see Mike is on leave on July 12 for the fisher RTM. Should we be inviting Nicole to

both the pre-RTM and RTM?

Wolverine:

We've got an SSA update scheduled w/ Noreen on June 15. John will be helping me circulate a briefing paper for the RD by Monday (6/12), needs to be to the RD's office that day or the briefing later next week will be cancelled.

Justin Shoemaker
Classification Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

From:	Shoemaker, Justin
To:	Jodi Bush; Marjorie Nelson
Cc:	Grizzle, Betty; Guinotte, John; Craig Hansen; Caitlin Snyder
Subject:	Wolverine briefing memo for RD
Date:	Friday, June 9, 2017 8:45:25 AM
Attachments:	Wolverine Detailed Timeline_06092017.docx Briefing Memo for RD_Wolverine SSA update_06092017.docx

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Jodi and Marj,

We have prepared a briefing memo for our wolverine SSA update for the RD next Thursday. This memo needs to be to the RD's office by Monday per R6 RD briefing guidance from Stephanie Potter. Please take a look and let me know if you have edits. We will be quickly circulating a surname folder through RO ES for Mike's signature on Monday.

We are trying to put together a genetics options paper as Mike requested. It can be an attachment to this memo if we get the necessary info regarding costs by Monday. Steve is looking into it. If not, I'll drop reference to the options paper in this memo but leave the topic for discussion.

We can also attach the revised schedule to the RD memo if you think appropriate. The latest draft is attached.

Justin Shoemaker
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Wolverine Listing Determination Timeline
6/9/17 version

Task	Responsible Parties	Dates	Length of time
Species Status Assessment (SSA) Phase			
FR notice opening comment period on 2013 proposed listing rule	MTFO	Oct 18 2016	done
DIP letters sent out to States and partners	MTFO	Oct	done
Public comment period, input from States, partners, etc.		Oct 18-Nov 17	30 days, done
Conduct science analysis (SSA)	SSA core team	By Sept 15 2017	in process
Draft SSA report	Betty Grizzle (FO Lead Bio)	By Oct 7	in process
SSA core team meeting in Denver	Core team, R6 management and decision support staff	Feb 15-16	2 days, done
SSA report check-in w/ RD	SSA core team, management	June 8	1 hr briefing
Peer review planning and contracting	Justin Shoemaker (ULT lead), Caitlin Snyder (ULT assist)	Aug - Oct	2 months to get contracted peer reviewers in place
SSA report core team review	SSA core team	Oct 7-14	1 week
Edit SSA report based on core team review	Betty Grizzle	Oct 14-Oct 21	1 week
SSA report to peer reviewers and partners*	Justin Shoemaker, Jodi Bush (MTFO Project Leader)	Oct 21-Nov 21	1 month
Edit and finalize SSA report	Betty Grizzle	Nov 21-Dec 19	4 weeks
Listing Decision Analysis Phase			
SSA report to recommendation team	Justin Shoemaker, Jodi Bush	Dec 19	At least 2 weeks prior to recommendation team meeting
Decision meeting	RDs or delegates, ARDs, other management, SSA core team	First or second week of Jan **2018**	2 days
Draft decision summary for the record or certify decision meeting notes	R6 RD or delegate	early Jan	3 days (after recommendation team meeting)
Process for final withdrawal of proposed listing (if decision is to not list) - or revised proposed listing rule (if decision is to list)			
Draft final withdrawal (not-warranted) FR notice or revised proposed listing rule (and if necessary, proposed 10(j), 4(d))	Justin Shoemaker and Betty Grizzle	Jan 15-Feb 12	4 weeks
Core team reviews FR notice,	SSA core team,	Feb 12-Feb 26	2 weeks

*Includes States, Tribes, Federal Agencies

make revisions	Justin Shoemaker		
Regional Office Surnames and concurrence	Marjorie Nelson, Mike Thabault, Matt Hogan, Noreen Walsh, and concurring regional RDs/ARDs or delegates	Feb 26-March 12	2 weeks
SOL surname	DOI SOL	Feb 26-March 12	2 weeks
PPM	PPM	Feb 26-March 12	2 weeks
Revise based on RO/SOL/PPM comments	Justin Shoemaker and Betty Grizzle	March 12-March 21	10 days
HQ review	Sarah Quamme, Bridget Fahey	March 21-	2 weeks (submit 6 weeks prior to FR submittal date)
Asst. Director for ES Surname	Asst. Director for ES	April 4	5 business days
FWS Director Surname	Director of FWS	April 11	5 business days
Fish, Wildlife, and Parks Surname	FWP	April 18	10 business days
Executive Secretary Surname	Executive Secretary's Office	May 2	3 business days
Deliver to FR	HQ	May 7	
Publication of withdrawal or proposed rule	Federal Register	May 14	
Public comment period on revised proposed listing (only if decision is to list)		May 14-June 12	30 days (may need to be 60 days, if so will revise)
Process for final listing Federal Register document			
Comment and response strategy meeting – develop plan to review and address comments received	SSA core team, management	Mid May (TBD)	half day
Review and address public comments on proposed listing	SSA core team, support staffing as needed from R6 RO	June 12-July 16	1 month
Meeting with decision team to discuss public comment and any new info, revisit decision	Marjorie Nelson, Mike Thabault, Matt Hogan, Noreen Walsh, and concurring regional RDs/ARDs or delegates	Early July 2018	half day
Draft final listing FR doc (if necessary 10(j), 4(d))	Justin Shoemaker and Betty Grizzle	by July 16	2 months from proposed listing publication
SSA core team reviews FR notice, make revisions	SSA core team	July 16-July 23	1 week
Regional Office Surnames and concurrence	Marjorie Nelson, Mike Thabault, Matt Hogan, Noreen Walsh, and	July 23-Aug 6	2 weeks

*Includes States, Tribes, Federal Agencies

	concurring regional RDs/ARDs or delegates		
SOL surname	DOI SOL	July 23-Aug 6	2 weeks
PPM	PPM	July 23-Aug 6	2 weeks
Revise based on RO/SOL/PPM comments	Justin Shoemaker and Betty Grizzle	Aug 6-Aug 13	1 week
HQ review	Sarah Quamme, Bridget Fahey	Aug 7	6 weeks prior to FR date (may need to start this review concurrent w/ RO,SOL, PPM revisions)
AES Surname	Assistant Director Ecological Services	Aug 21	5 business days
FWS Director Signature	Director of FWS	Aug 28	5 business days
Fish, Wildlife, and Parks Surname	FWP	Sep 5	10 business days
Executive Secretary Surname	Executive Secretary's Office	Sep 19	3 business days
Deliver to FR	HQ	Sep 24	
Publication of final rule	Federal Register	Sep 28, 2018	Note: We've committed to final rule in FY 18 in the work plan

*Includes States, Tribes, Federal Agencies

BRIEFING MEMORANDUM FOR THE REGIONAL DIRECTOR

DATE: June 9, 2017

FROM: Michael Thabault, Assistant Regional Director, Ecological Services

SUBJECT: Wolverine Species Status Assessment Update

To inform the Regional Director of the progress made on the wolverine Species Status Assessment (SSA) and the key information that will be of interest to the eventual wolverine listing decision. Briefing scheduled for June 15.

BACKGROUND

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DISCUSSION

Highlighted in Judge Christensen's Court order remanding the withdrawal were the Service's determinations regarding: (a) the threat posed to the wolverine by the effects of climate change at the reproductive denning scale, (b) the threat posed to the wolverine by small population size and lack of genetic diversity, and (c) application of the SPR Policy to the wolverine. In our SSA we are making every effort to inform these points and ensure we are using the most up-to-date science upon which to base our listing decision.

Range of the species – Our current approach to delineating wolverine range in the lower 48 is different, and we believe more accurate, than the broader range considered in the 2014 withdrawal.

Trapping Data – We have gathered additional trapping data not available to us in 2014 to inform the range of the species and the effect of trapping in Canada (British Columbia and Alberta) as it relates to an updated DPS determination.

NOAA/CU snow persistence model – High resolution snow pack models have been developed for Glacier and Rocky Mountain National Parks. These areas bracket the DPS range in the lower 48. The majority of model scenarios indicate significant future snow persistence through April and May for elevations currently used for denning (Glacier) and the inferred elevations where wolverines would be expected to den in Rocky Mountain National Park.

New denning information – We have several records that were not available to us in 2014 of den sites found outside of modeled snow habitat in North America, as well as confirmation of successful wolverine dens outside of snow in Scandinavia.

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Genetics – The court said that, in our 2014 withdrawal, we failed to articulate how our statements regarding the following did not constitute adverse effects to wolverine:

- Apparent loss of connectivity between Rocky Mountains and Canada prevented influx of genetic material needed to maintain or increase the genetic diversity in contiguous U.S.
- Effective population size is too low to support the subpopulations in contiguous U.S.
- Genetic drift has already occurred in subpopulations in contiguous U.S. as compared to Canada, and a continued loss of genetic diversity may lead to inbreeding depression and inability of wolverines in contiguous U.S. to persist

Thus, we need to evaluate our statements in previous rules that there is "good evidence" that genetic diversity is lower in wolverines in the contiguous U.S. as compared to Canada and Alaska. We also need to determine whether there is a threat for inbreeding depression based on small population. In addition to informing these points, knowledge gained through a more thorough and complete comparison of the genetic structure of wolverine population in the contiguous U.S. as well as Alaska and Canada would provide a more legally and scientifically robust basis on which to base our DPS determination.

See attached options paper.

NEXT STEPS

We plan to have the final SSA report, with peer and partner review incorporated, to the RD and decision team by December 2017.

ATTACHMENTS

Wolverine SSA and listing decision schedule attached.

Genetics options paper.

From: Hansen, Craig
To: Shoemaker, Justin
Cc: Marjorie Nelson
Subject: Re: Wolverine briefing memo for RD
Date: Friday, June 9, 2017 9:25:39 AM

Justin:

I reviewed. They look good to me and I have no comments at this time.

Craig.

2017-04-10_Email_Signature_3.jpg

On Fri, Jun 9, 2017 at 8:45 AM, Shoemaker, Justin <justin_shoemaker@fws.gov> wrote:

> Jodi and Marj,
>
> We have prepared a briefing memo for our wolverine SSA update for the RD next Thursday. This memo needs to be to the RD's office by Monday per R6 RD briefing guidance from Stephanie Potter. Please take a look and let me know if you have edits. We will be quickly circulating a surname folder through RO ES for Mike's signature on Monday.
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> Justin Shoemaker
> Classification Biologist
> U.S. Fish and Wildlife Service, Region 6
> Phone: 309-757-5800 x214
> Email: justin_shoemaker@fws.gov

From:	Shoemaker, Justin
To:	Bush, Jodi
Cc:	Betty Grizzle
Subject:	Re: Wolverine briefing memo for RD
Date:	Friday, June 9, 2017 1:27:27 PM

Jodi,

In response to your first point, I may add the following just above the topics for discussion:

"The following topics for discussion either directly inform the points highlighted by the Court or inform data gaps/uncertainties that are highly relevant to our DPS and listing decision for wolverine."

As far as next steps, I'm not sure what to add. We need to have the SSA to RD in Dec regardless of PVA and genetics. But maybe a next step is to decide to pursue or not pursue genetics?

And the genetics options paper is under construction, will be a revision of the talking points paper. I'll send it along when drafted.

Justin Shoemaker
Classification Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

On Fri, Jun 9, 2017 at 10:57 AM, Bush, Jodi <jodi_bush@fws.gov> wrote:

> Looks pretty good Justin. One minor thing - paragraph runs into last bullet on last page.
>
> A couple of points.
>
> - Because we are trying to address Judges decision, we might want to be more explicit about which points are in response to the issues identified by the judge (a,b,c), so Noreen et al can follow. I don't remember DPS being part of the Judge's decision - other than not deciding.   Maybe I missed it.
> - Wondering if we want to be more pointed about next steps. This is our date if we have the information from the additional PVA and genetics study (if pursued).
> - Assuming that the options paper was constructed from the talking points paper that you guys had previously completed last week? It wasn't included in the email.
>
> Otherwise looks fine. JB
>
> Jodi L. Bush
> Office Supervisor

Montana State Ecological Services Office
585 Shepard Way, Suite 1
Helena, MT 59601
(406) 449-5225, ext.205

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Justin Shoemaker
Classification Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

From:	Nelson, Marjorie
To:	Shoemaker, Justin
Cc:	Jodi Bush; Grizzle, Betty; Guinotte, John; Craig Hansen; Caitlin Snyder
Subject:	Re: Wolverine briefing memo for RD
Date:	Friday, June 9, 2017 1:46:36 PM
Attachments:	Briefing Memo for RD Wolverine SSA update 06092017 MN.docx

Just the one comment pending Mike's review of the options paper.

Marjorie Nelson
Chief, Division of Ecological Services
Mountain-Prairie Region
U.S. Fish and Wildlife Service
DIFFERENT NUMBER UNTIL 6TH FLOOR FIXED
720-582-3524

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FROM: Michael Thabault, Assistant Regional Director, Ecological Services

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See attached options paper.

Commented [NM1]: Let's have the options paper get Mike's review before inserting.

NEXT STEPS

We plan to have the final SSA report, with peer and partner review incorporated, to the RD and decision team by December 2017.

ATTACHMENTS

Wolverine SSA and listing decision schedule attached.

Genetics options paper.

From: Grizzle, Betty
To: Shoemaker, Justin
Cc: Jodi Bush; Marjorie Nelson; Guinotte, John; Craig Hansen; Caitlin Snyder
Subject: Re: Wolverine briefing memo for RD
Date: Sunday, June 11, 2017 4:00:33 PM
Attachments: Briefing Memo for RD Wolverine SSA update 20170611 BJG edits.docx

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Hi all - I came in today (Sunday) to review the briefing memo document since this is due Monday morning.
I worked from the original document that was sent to me by John Guinotte on June 9, though I realize that there have been a few subsequent reviews and changes made since then. **Please see attached file for a few minor and substantive changes.**
I will be back in the office on Monday if you have questions.

On Fri, Jun 9, 2017 at 7:45 AM, Shoemaker, Justin <justin_shoemaker@fws.gov> wrote:

> Jodi and Marj,
>
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--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

BRIEFING MEMORANDUM FOR THE REGIONAL DIRECTOR

DATE: June 7, 2017

FROM: Michael Thabault, Assistant Regional Director, Ecological Services

SUBJECT: North American Wolverine Species Status Assessment Update

To inform the Regional Director of the progress made on the North American wolverine (wolverine) Species Status Assessment (SSA) Report and the key information that will be of interest to the eventual wolverine listing decision. A briefing is scheduled for June 15.

BACKGROUND

In compliance with a Court order that remanded our previous withdrawal of a proposed rule to list the contiguous U.S. Distinct Population Segment (DPS) of the wolverine (79 FR 47522; August 13, 2014), we will prepare either a revised proposed rule to list or a revised withdrawal of the previous proposed rule (78 FR 7864; February 4, 2013). In October 2016, we published a notice to announce the vacature of the withdrawal rule to the public, announce the proposed status since the judge's ruling, and to reopen the public comment period on the February 4, 2013 proposed rule to list the wolverine as a threatened species.

DISCUSSION

Highlighted in Judge Christensen's Court order remanding the withdrawal were the Service's determinations regarding: (a) the threat posed to the wolverine by the effects of climate change at the reproductive denning scale, (b) the threat posed to the wolverine by small population size and lack of genetic diversity, and (c) application of the SPR Policy to the wolverine. In our SSA Report we are reviewing previously considered information and new information to inform these points to ensure we are using the best available science upon which to base our listing decision.

Range of the Species – using both previously considered and new information, we have revised our approach to delineate the range of the wolverine across North America and in the contiguous United States ; to more accurately represent the species' range.

Trapping Data – we have collected additional trapping data not available to us in 2014 to inform the range of the species and the effect of trapping in Canada (British Columbia and Alberta); this information is directly relevant to informing our DPS determination.

NOAA/CU snow persistence model – High resolution snow pack models have been developed for Glacier and Rocky Mountain National Parks. These areas bracket the DPS range for the wolverine in the contiguous United States. The majority of model scenarios indicate significant future snow persistence through April and May for 1) elevations currently used for denning (Glacier) and 2) the inferred elevations where wolverines would be expected to den in Rocky Mountain National Park.

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New denning information – we have received several peer-reviewed publications and other information from wolverine researchers that were not available to us in 2014 documenting natal den sites and den site conditions that provide new insight into the timing and location of wolverine den sites; natal den sites have been documented in locations outside of areas previously predicted by Copeland et al. (2010) snow model in North America and in Scandinavia.

Population Viability Analysis (PVA) underway – we are coordinating with USGS to develop a PVA to inform minimum viable population size and to develop future scenarios that model the potential effects of demographic and habitat parameters on the wolverine population in the contiguous United States.

Genetics – see attached options paper.

NEXT STEPS

We plan to present the final SSA Report, with peer and partner review incorporated, to the RD and decision team by December 2017.

ATTACHMENTS

Schedule for preparation of the North American wolverine SSA Report and listing decision documents is attached.

Genetics options paper.

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Commented [SJ1]: We can revise the paper we put together for Mike w/ actual $ amounts.

From:	Bush, Jodi
To:	Grizzle, Betty
Cc:	Shoemaker, Justin
Subject:	Re: Wolverine briefing memo for RD
Date:	Monday, June 12, 2017 8:05:24 AM

These changes look good to me. JB

Jodi L. Bush
Office Supervisor
Montana State Ecological Services Office
585 Shepard Way, Suite 1
Helena, MT 59601
(406) 449-5225, ext.205

On Sun, Jun 11, 2017 at 4:00 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:

> Hi all - I came in today (Sunday) to review the briefing memo document since this is due Monday morning.
> I worked from the original document that was sent to me by John Guinotte on June 9, though I realize that there have been a few subsequent reviews and changes made since then.
> **Please see attached file for a few minor and substantive changes.**
> I will be back in the office on Monday if you have questions.
>
> On Fri, Jun 9, 2017 at 7:45 AM, Shoemaker, Justin <justin_shoemaker@fws.gov> wrote:
>
>> Jodi and Marj,
>>
>> We have prepared a briefing memo for our wolverine SSA update for the RD next Thursday. This memo needs to be to the RD's office by Monday per R6 RD briefing guidance from Stephanie Potter. Please take a look and let me know if you have edits. We will be quickly circulating a surname folder through RO ES for Mike's signature on Monday.
>>
>> We are trying to put together a genetics options paper as Mike requested. It can be an attachment to this memo if we get the necessary info regarding costs by Monday. Steve is looking into it. If not, I'll drop reference to the options paper in this memo but leave the topic for discussion.
>>
>> We can also attach the revised schedule to the RD memo if you think appropriate. The latest draft is attached.
>>
>> Justin Shoemaker
>> Classification Biologist
>> U.S. Fish and Wildlife Service, Region 6
>> Phone: 309-757-5800 x214
>> Email: justin_shoemaker@fws.gov
>
> --

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

From:	Shoemaker, Justin
To:	Grizzle, Betty; Guinotte, John
Cc:	Jodi Bush
Subject:	wolverine RD briefing memo 6/12 version
Date:	Monday, June 12, 2017 8:44:56 AM
Attachments:	Briefing Memo for RD_Wolverine SSA update_06122017.docx

Betty and John,

I've taken the last version that Betty reviewed and added in some info to the Genetics section. Unless Steve gets us some real dollar amounts to use, I don't see having the genetics options paper ready in time to include w/ this memo. So thought we should have some points in that section to discuss. I left "see genetics options paper" in there, but we can take out if needed. Let me know what you think and we'll get this moving through surname.

Justin Shoemaker
Classification Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

BRIEFING MEMORANDUM FOR THE REGIONAL DIRECTOR

DATE: June 12, 2017

FROM: Michael Thabault, Assistant Regional Director, Ecological Services

SUBJECT: Wolverine Species Status Assessment Update

To inform the Regional Director of the progress made on the North American wolverine (wolverine) Species Status Assessment (SSA) Report and the key information that will be of interest to the eventual wolverine listing decision. A briefing is scheduled for June 15.

BACKGROUND

In compliance with a Court order that remanded our previous withdrawal of a proposed rule to list the contiguous U.S. Distinct Population Segment (DPS) of the wolverine (79 FR 47522; August 13, 2014), we will prepare either a revised proposed rule to list or a revised withdrawal of the previous proposed rule (78 FR 7864; February 4, 2013). In October 2016, we published a notice to announce the vacature of the withdrawal rule to the public, announce the proposed status since the judge's ruling, and to reopen the public comment period on the February 4, 2013 proposed rule to list the wolverine as a threatened species.

DISCUSSION

Highlighted in Judge Christensen's Court order remanding the withdrawal were the Service's determinations regarding: (a) the threat posed to the wolverine by the effects of climate change at the reproductive denning scale, (b) the threat posed to the wolverine by small population size and lack of genetic diversity, and (c) application of the SPR Policy to the wolverine. In our SSA Report we are reviewing previously considered information and new information to inform these points to ensure we are using the best available science upon which to base our listing decision.

Range of the Species – using both previously considered and new information, we have revised our approach to delineate the range of the wolverine across North America and in the contiguous United States ; to more accurately represent the species' range.

Trapping Data – we have collected additional trapping data not available to us in 2014 to inform the range of the species and the effect of trapping in Canada (British Columbia and Alberta); this information is directly relevant to informing our DPS determination.

NOAA/CU snow persistence model – High resolution snow pack models have been developed for Glacier and Rocky Mountain National Parks. These areas bracket the DPS range for the wolverine in the contiguous United States. The majority of model scenarios indicate significant future snow persistence through April and May for 1) elevations currently used for denning (Glacier) and 2) the inferred elevations where wolverines would be expected to den in Rocky Mountain National Park.

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Deleted: Briefing

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The following topics for discussion either directly inform the points highlighted by the Court or inform data gaps/uncertainties that are highly relevant to our DPS and listing decision for wolverine. ¶

New denning information – we have received several peer-reviewed publications and other information from wolverine researchers that were not available to us in 2014 documenting natal den sites and den site conditions that provide new insight into the timing and location of wolverine den sites; natal den sites have been documented in locations outside of areas previously predicted by Copeland et al. (2010) snow model in North America and in Scandinavia.

Population Viability Analysis (PVA) underway – we are coordinating with USGS to develop a PVA to inform minimum viable population size and to develop future scenarios that model the potential effects of demographic and habitat parameters on the wolverine population in the contiguous United States.

Genetics – The court said that, in our 2014 withdrawal, we failed to articulate how our statements regarding the following did not constitute adverse effects to wolverine:

- Apparent loss of connectivity between Rocky Mountains and Canada prevented influx of genetic material needed to maintain or increase the genetic diversity in contiguous U.S.
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- Genetic drift has already occurred in subpopulations in contiguous U.S. as compared to Canada, and a continued loss of genetic diversity may lead to inbreeding depression and inability of wolverines in contiguous U.S. to persist.

Thus, we need to evaluate our statements in previous rules that there is “good evidence” that genetic diversity is lower in wolverines in the contiguous U.S. as compared to Canada and Alaska. We also need to determine whether there is a threat for inbreeding depression based on small population. In addition to informing these points, knowledge gained through a more thorough and complete comparison of the genetic structure of wolverine population in the contiguous U.S. as well as Alaska and Canada would provide a more legally and scientifically robust basis on which to base our DPS determination.

See attached options paper.

NEXT STEPS

We plan to present the final SSA Report, with peer and partner review incorporated, to the RD and decision team by December 2017.

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Deleted: Wolverine SSA and listing decision schedule attached. ¶

From:	Grizzle, Betty
To:	Shoemaker, Justin
Cc:	Guinotte, John; Jodi Bush
Subject:	Re: wolverine RD briefing memo 6/12 version
Date:	Monday, June 12, 2017 9:08:21 AM
Attachments:	Briefing Memo for RD Wolverine SSA update 06122017 BJGedits.docx

See attached for edits/suggestions.

On Mon, Jun 12, 2017 at 7:44 AM, Shoemaker, Justin <justin_shoemaker@fws.gov> wrote:

> Betty and John,
>
> I've taken the last version that Betty reviewed and added in some info to the Genetics section. Unless Steve gets us some real dollar amounts to use, I don't see having the genetics options paper ready in time to include w/ this memo. So thought we should have some points in that section to discuss. I left "see genetics options paper" in there, but we can take out if needed. Let me know what you think and we'll get this moving through surname.
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> Justin Shoemaker
> Classification Biologist
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> Phone: 309-757-5800 x214
> Email: justin_shoemaker@fws.gov

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

BRIEFING MEMORANDUM FOR THE REGIONAL DIRECTOR

DATE: June 12, 2017

FROM: Michael Thabault, Assistant Regional Director, Ecological Services

SUBJECT: Wolverine Species Status Assessment Update

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Deleted: Wolverine SSA and listing decision schedule attached. ¶

From:	Trina Vigil
To:	Craig Hansen
Cc:	John Guinotte; Justin Shoemaker; trina_vigil@fws.gov
Subject:	Surname Package: BP Memo Wolverine
Date:	Monday, June 12, 2017 12:17:14 PM
Attachments:	image002.png Briefing Memo for RD_Wolverine SSA update_06122017.docx Surname Pkg Note to Reviewer.docx surname_list.pdf Wolverine Detailed Timeline_06122017.docx Surname Pkg Routing List.doc
Importance:	High

Craig-

Good afternoon, can you please surname the attached surname package. Make sure to sign the Yellow Surname sheet once you have approved it please forward it to next person on the routing sheet and reply to all to allow the author and myself able to track the location of the surname package. If you make any changes to any of the documents please make the changes on the I:\drive document and attach the new version of the document to the email.

All documents can be found at the following location: I:\- Surname Word Document\Surname ES\Shoemaker\BP Wolverine

Note: Needs to be delivered to RD office today

ECOLOGICAL SERVICES

#	NAME /TITLE/ OFFICE	LTR*
	Field Office -	F
	Backsen, Sarah	F
	Boroja, Maria	F
	Burgess, Angela	F
	Burgess, Kevin	F
	Gober, Joy	F
	Guinotte, John	F
2	Hansen, Craig	F
	Joersz, Kiana	
	Juliusson, Lara	F
	Kelleher, John/Eileen Lindgren	F
	Konishi, Kathy	F
	Laye, Doug	F
	Lickfett, Todd	F
	Norman, Kate	F
	Orton-Palmer, Amelia	F
	Sattelberg, Mark	F
1	Shoemaker, Justin	F
	Skorupa, Joe	F
	Smith, Kim	F
	Wiechman, Lief	F
3	Nelson, Marjorie/ Chief – Ecological Services	F
	Kales, Matt	F
	Vigil, Trina/Secretary/ ES	F
	Naylon, Jill/Secretary/ES	F
	Alt, Nicole/ Deputy ARD-ES	F / G
4	Thabault, Mike / ARD-ES	F / G
5	Regional Director / Deputy RD	F / G
	External Affairs	F
	Budget Administration	F
	Fisheries	F
	Law Enforcement	F
	Migratory Birds / State Programs	F
	Refuges	F
	Ecological Services	H

* **F** -- surname **G** -- signature **H** -- return to originating office

FROM: Trina Vigil **DATE:** 6/12/17

Trina Vigil
Administrative Support Assistant
134 Union Blvd
Lakewood, CO 80228
(303) 236-4253

ECOLOGICAL SERVICES

#	NAME /TITLE/ OFFICE	LTR*
	Field Office -	F
	Backsen, Sarah	F
	Boroja, Maria	F
	Burgess, Angela	F
	Burgess, Kevin	F
	Gober, Joy	F
	Guinotte, John	F
2	Hansen, Craig	F
	Joersz, Kiana	
	Juliusson, Lara	F
	Kelleher, John/Eileen Lindgren	F
	Konishi, Kathy	F
	Laye, Doug	F
	Lickfett, Todd	F
	Norman, Kate	F
	Orton-Palmer, Amelia	F
	Sattelberg, Mark	F
1	Shoemaker, Justin	F
	Skorupa, Joe	F
	Smith, Kim	F
	Wiechman, Lief	F
3	Nelson, Marjorie/ Chief – Ecological Services	F
	Kales, Matt	F
	Vigil, Trina/Secretary/ ES	F
	Naylon, Jill/Secretary/ES	F
	Alt, Nicole/ Deputy ARD-ES	F / G
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	Ecological Services	H

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FROM: Trina Vigil DATE: 6/12/17

BRIEFING MEMORANDUM FOR THE REGIONAL DIRECTOR

DATE: June 12, 2017

FROM: Michael Thabault, Assistant Regional Director, Ecological Services

SUBJECT: Wolverine Species Status Assessment Update

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NEXT STEPS

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ATTACHMENTS

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NOTE TO REVIEWER (NTR)

DATE SUBMITTED: June 12, 2017

PREPARED BY: Justin Shoemaker, Classification Biologist, for Mike Thabault

SUBJECT: BRIEFING MEMORANDUM ON THE NORTH AMERICAN WOLVERINE FOR THE REGIONAL DIRECTOR

CRITICAL DATES (if any): **June 15, 2017, In-Person Briefing**

DESCRIPTION/MAIN MESSAGE:

- **THE BRIEFING MEMORANDUM IS TO INFORM THE REGIONAL DIRECTOR OF THE PROGRESS MADE ON THE NORTH AMERICAN WOLVERINE SPECIES STATUS ASSESSMENT REPORT AND THE KEY INFORMATION THAT WILL BE OF INTEREST TO THE WOLVERINE LISTING DECISION.**
- **AN IN-PERSON BRIEFING IS SCHEDULED FOR JUNE 15, 2017 AT 1PM (MST).**
- **BRIEFING TOPICS INCLUDE: UPDATED CURRENT RANGE OF THE SPECIES, TRAPPING DATA IN CANADA, NOAA/CU SNOW PERSISTENCE MODEL, NEW DENNING INFORMATION, POPULATION VIABILITY ANALYSIS AND GENETICS**

SURNAME		
TITLE	NAME	DATE
FIELD OFFICE		
AUTHOR Justin Shoemaker	[signature]	6/12/17
FIELD OFFICE SUPERVISOR/PL		
FIELD OFFICE ADMIN ASSISTANT / FIELD OFFICE ADMINISTRATIVE OFFICER		
REGIONAL OFFICE		
AUTHOR / RO LEAD		
SECRETARY	[initials]	6/12/17
ARD- SCIENCE APPLICATIONS		
ARD – ECOLOGICAL SERVICES		
DARD-ECOLOGICAL SERVICES		
ARD – EXTERNAL AFFAIRS		
ARD – FISHERIES		
ARD – LAW ENFORCEMENT		
ARD – MIGRATORY BIRDS		
ARD – NATL WILDLIFE REFUGE SYSTEM		
ARD- BUDGET/ADMINISTRATION		
CHIEF OF STAFF/RD OFFICE		
SECRETARY / REGIONAL DIRECTOR		
DEPUTY REGIONAL DIRECTOR		
REGIONAL DIRECTOR		
ECOLOGICAL SERVICE REGIONAL OFFICE		
BRANCH CHIEF, CLASSIFICATION AND RECOVERY		
BRANCH CHIEF, LANDSCAPE CONSERVATION AND RESTORATION		
BRANCH CHIEF, DECISION SUPPORT		
DIVISION CHIEF, ECOLOGICAL SERVICES		
DISTRIBUTED (FED EX) (USPS) CIRCLE ONE		

Wolverine Listing Determination Timeline
6/12/17 version

Task	Responsible Parties	Dates	Length of time
	Species Status Assessment (SSA) Phase		
FR notice opening comment period on 2013 proposed listing rule	MTFO	Oct 18 2016	done
DIP letters sent out to States and partners	MTFO	Oct	done
Public comment period, input from States, partners, etc.		Oct 18-Nov 17	30 days, done
Conduct science analysis (SSA)	SSA core team	By Sept 15 2017	in process
Draft SSA report	Betty Grizzle (FO Lead Bio)	By Oct 7	in process
SSA core team meeting in Denver	Core team, R6 management and decision support staff	Feb 15-16	2 days, done
SSA report check-in w/ RD	SSA core team, management	June 8	1 hr briefing
Peer review planning and contracting	Justin Shoemaker (ULT lead), Caitlin Snyder (ULT assist)	Aug - Oct	2 months to get contracted peer reviewers in place
SSA report core team review	SSA core team	Oct 7-14	1 week
Edit SSA report based on core team review	Betty Grizzle	Oct 14-Oct 21	1 week
SSA report to peer reviewers and partners*	Justin Shoemaker, Jodi Bush (MTFO Project Leader)	Oct 21-Nov 21	1 month
Edit and finalize SSA report	Betty Grizzle	Nov 21-Dec 19	4 weeks
	Listing Decision Analysis Phase		
SSA report to recommendation team	Justin Shoemaker, Jodi Bush	Dec 19	At least 2 weeks prior to recommendation team meeting
Decision meeting	RDs or delegates, ARDs, other management, SSA core team	First or second week of Jan **2018**	2 days
Draft decision summary for the record or certify decision meeting notes	R6 RD or delegate	early Jan	3 days (after recommendation team meeting)
	Process for final withdrawal of proposed listing (if decision is to not list) - or revised proposed listing rule (if decision is to list)		
Draft final withdrawal (not-warranted) FR notice or revised proposed listing rule (and if necessary, proposed 10(j), 4(d))	Justin Shoemaker and Betty Grizzle	Jan 15-Feb 12	4 weeks
Core team reviews FR notice,	SSA core team,	Feb 12-Feb 26	2 weeks

*Includes States, Tribes, Federal Agencies

make revisions	Justin Shoemaker		
Regional Office Surnames and concurrence	Marjorie Nelson, Mike Thabault, Matt Hogan, Noreen Walsh, and concurring regional RDs/ARDs or delegates	Feb 26-March 12	2 weeks
SOL surname	DOI SOL	Feb 26-March 12	2 weeks
PPM	PPM	Feb 26-March 12	2 weeks
Revise based on RO/SOL/PPM comments	Justin Shoemaker and Betty Grizzle	March 12-March 21	10 days
HQ review	Sarah Quamme, Bridget Fahey	March 21-	2 weeks (submit 6 weeks prior to FR submittal date)
Asst. Director for ES Surname	Asst. Director for ES	April 4	5 business days
FWS Director Surname	Director of FWS	April 11	5 business days
Fish, Wildlife, and Parks Surname	FWP	April 18	10 business days
Executive Secretary Surname	Executive Secretary's Office	May 2	3 business days
Deliver to FR	HQ	May 7	
Publication of withdrawal or proposed rule	Federal Register	May 14	
Public comment period on revised proposed listing (only if decision is to list)		May 14-June 12	30 days (may need to be 60 days, if so will revise)
Process for final listing Federal Register document			
Comment and response strategy meeting – develop plan to review and address comments received	SSA core team, management	Mid May (TBD)	half day
Review and address public comments on proposed listing	SSA core team, support staffing as needed from R6 RO	June 12-July 16	1 month
Meeting with decision team to discuss public comment and any new info, revisit decision	Marjorie Nelson, Mike Thabault, Matt Hogan, Noreen Walsh, and concurring regional RDs/ARDs or delegates	Early July 2018	half day
Draft final listing FR doc (if necessary 10(j), 4(d))	Justin Shoemaker and Betty Grizzle	by July 16	2 months from proposed listing publication
SSA core team reviews FR notice, make revisions	SSA core team	July 16-July 23	1 week
Regional Office Surnames and concurrence	Marjorie Nelson, Mike Thabault, Matt Hogan, Noreen Walsh, and	July 23-Aug 6	2 weeks

*Includes States, Tribes, Federal Agencies

	concurring regional RDs/ARDs or delegates		
SOL surname	DOI SOL	July 23-Aug 6	2 weeks
PPM	PPM	July 23-Aug 6	2 weeks
Revise based on RO/SOL/PPM comments	Justin Shoemaker and Betty Grizzle	Aug 6-Aug 13	1 week
HQ review	Sarah Quamme, Bridget Fahey	Aug 7	6 weeks prior to FR date (may need to start this review concurrent w/ RO,SOL, PPM revisions)
AES Surname	Assistant Director Ecological Services	Aug 21	5 business days
FWS Director Signature	Director of FWS	Aug 28	5 business days
Fish, Wildlife, and Parks Surname	FWP	Sep 5	10 business days
Executive Secretary Surname	Executive Secretary's Office	Sep 19	3 business days
Deliver to FR	HQ	Sep 24	
Publication of final rule	Federal Register	Sep 28, 2018	Note: We've committed to final rule in FY 18 in the work plan

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ECOLOGICAL SERVICES

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	Boroja, Maria	F
	Burgess, Angela	F
	Burgess, Kevin	F
	Gober, Joy	F
	Guinotte, John	F
2	Hansen, Craig	F
	Joersz, Kiana	
	Juliusson, Lara	F
	Kelleher, John/Eileen Lindgren	F
	Konishi, Kathy	F
	Laye, Doug	F
	Lickfett, Todd	F
	Norman, Kate	F
	Orton-Palmer, Amelia	F
	Sattelberg, Mark	F
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	Smith, Kim	F
	Wiechman, Lief	F
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	Kales, Matt	F
	Vigil, Trina/Secretary/ ES	F
	Naylon, Jill/Secretary/ES	F
	Alt, Nicole/ Deputy ARD-ES	F / G
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	Budget Administration	F
	Fisheries	F
	Law Enforcement	F
	Migratory Birds / State Programs	F
	Refuges	F
	Ecological Services	H

* **F** -- surname **G** -- signature **H** -- return to originating office

FROM: **Trina Vigil** **DATE: 6/12/17**

From:	Guinotte, John
To:	Nelson, Marjorie; Michael Thabault
Cc:	Shoemaker, Justin; Hansen, Craig; Trina Vigil
Subject:	surname package for wolverine briefing with the RD
Date:	Monday, June 12, 2017 12:26:28 PM

Hi Marj and Mike,

Just a quick heads up that a surname package will be heading your way shortly on the wolverine briefing memorandum for the regional director. It is with Craig now. The package needs to be delivered to the RD office by end of the day today. I'm in my office if anything comes up. I have a hard copy and Craig has the digital version.

Thanks John

John Guinotte
Fish and Wildlife Biologist
Ecological Services
U.S. Fish and Wildlife Service
Mountain Prairie Region 6
134 Union Blvd., Lakewood, CO 80228
303-236-4264
john_guinotte@fws.gov

From:	Hansen, Craig
To:	Trina Vigil
Cc:	John Guinotte; Justin Shoemaker
Subject:	Re: Surname Package: BP Memo Wolverine
Date:	Monday, June 12, 2017 12:28:51 PM
Attachments:	image002.png

Copy. Received. Reviewing now.

Craig.

2017-04-10_Email_Signature_3.jpg

On Mon, Jun 12, 2017 at 12:16 PM, Trina Vigil <trina_vigil@fws.gov> wrote:

> Craig-
>
> Good afternoon, can you please surname the attached surname package. Make sure to sign the Yellow Surname sheet once you have approved it please forward it to next person on the routing sheet and reply to all to allow the author and myself able to track the location of the surname package. If you make any changes to any of the documents please make the changes on the I:\drive document and attach the new version of the document to the email.
>
> All documents can be found at the following location: I:\- Surname Word Document\Surname ES\Shoemaker\BP Wolverine
>
> **Note: Needs to be delivered to RD office today**

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	Budget Administration	F
	Fisheries	F
	Law Enforcement	F
	Migratory Birds / State Programs	F
	Refuges	F
	Ecological Services	H
* F -- surname G -- signature H -- return to originating office		
FROM: Trina Vigil	DATE: 6/12/17	

Trina Vigil

Administrative Support Assistant

134 Union Blvd

Lakewood, CO 80228

(303) 236-4253

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FROM: Trina Vigil **DATE:** 6/12/17

From:	Hansen, Craig
To:	Marjorie Nelson
Cc:	John Guinotte; Justin Shoemaker; Trina Vigil
Subject:	Re: Surname Package: BP Memo Wolverine
Date:	Monday, June 12, 2017 12:45:42 PM
Attachments:	image002.png Briefing Memo for RD Wolverine SSA update 06122017.docx Surname Pkg Note to Reviewer.docx Wolverine Detailed Timeline 06122017.docx Surname Pkg Routing List.doc surname list 2.pdf

Marj:

I have surnamed this package.   I made no edits to the original files.   It is now in your hands.

Trina's instructions follow:

Thank you all,

Craig.

2017-04-10_Email_Signature_3.jpg

On Mon, Jun 12, 2017 at 12:16 PM, Trina Vigil <trina_vigil@fws.gov> wrote:

> Craig-
>
> Good afternoon, can you please surname the attached surname package. Make sure to sign the Yellow Surname sheet once you have approved it please forward it to next person on the routing sheet and reply to all to allow the author and myself able to track the location of the surname package. If you make any changes to any of the documents please make the changes on the I:\drive document and attach the new version of the document to the email.
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FROM: Trina Vigil	DATE: 6/12/17	

Trina Vigil

Administrative Support Assistant

134 Union Blvd

Lakewood, CO 80228

(303) 236-4253

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FROM: Trina Vigil **DATE:** 6/12/17

BRIEFING MEMORANDUM FOR THE REGIONAL DIRECTOR

DATE: June 12, 2017

FROM: Michael Thabault, Assistant Regional Director, Ecological Services

SUBJECT: Wolverine Species Status Assessment Update

To inform the Regional Director of the progress made on the North American wolverine (wolverine) Species Status Assessment (SSA) Report and the key information that will be of interest to the eventual wolverine listing decision. A briefing is scheduled for June 15.

BACKGROUND

In compliance with a Court order that remanded our previous withdrawal of a proposed rule to list the contiguous U.S. Distinct Population Segment (DPS) of the wolverine (79 FR 47522; August 13, 2014), we will prepare either a revised proposed rule to list or a revised withdrawal of the previous proposed rule (78 FR 7864; February 4, 2013). In October 2016, we published a notice to announce the vacature of the withdrawal rule to the public, announce the proposed status since the judge's ruling, and to reopen the public comment period on the February 4, 2013 proposed rule to list the wolverine as a threatened species.

DISCUSSION

Highlighted in Judge Christensen's Court order remanding the withdrawal were the Service's determinations regarding: (a) the threat posed to the wolverine by the effects of climate change at the reproductive denning scale, (b) the threat posed to the wolverine by small population size and lack of genetic diversity, and (c) application of the SPR Policy to the wolverine. In our SSA Report we are reviewing previously considered information and new information to inform these points to ensure we are using the best available science upon which to base our listing decision.

Range of the Species – using both previously considered and new information, we have revised our approach to delineate the range of the wolverine across North America and in the contiguous United States to more accurately represent the species' range.

Trapping Data – we have collected additional trapping data not available to us in 2014 to inform the range of the species and the effect of trapping in Canada (British Columbia and Alberta); this information is directly relevant to informing our DPS determination.

NOAA/CU snow persistence model – High resolution snow pack models have been developed for Glacier and Rocky Mountain National Parks. These areas bracket the DPS range for the wolverine in the contiguous United States. The majority of model scenarios indicate significant future snow persistence through April and May for 1) elevations currently used for denning in Glacier National Park and 2) the inferred elevations where wolverines would be expected to den in Rocky Mountain National Park.

New denning information – we have received several peer-reviewed publications and other information from wolverine researchers that were not available to us in 2014 documenting natal den sites and den site conditions that provide new insight into the timing and location of wolverine den sites; natal den sites have been documented in locations outside of areas previously predicted by Copeland et al. (2010) snow model in North America and in Scandinavia.

Population Viability Analysis (PVA) underway – we are coordinating with USGS to develop a PVA to inform minimum viable population size and to develop future scenarios that model the potential effects of demographic and habitat parameters on the wolverine population in the contiguous United States.

Genetics – The court stated that, in our 2014 withdrawal, we failed to articulate how our statements regarding the following did not constitute adverse effects to wolverine:

- Apparent loss of connectivity between Rocky Mountains and Canada prevented influx of genetic material needed to maintain or increase the genetic diversity in contiguous U.S.
- Effective population size is too low to support the subpopulations in contiguous U.S.
- Genetic drift has already occurred in subpopulations in contiguous U.S. as compared to Canada, and a continued loss of genetic diversity may lead to inbreeding depression and inability of wolverines in contiguous U.S. to persist.

To address these concerns we need to evaluate our analysis in previous rules in which we concluded that there is "good evidence" that genetic diversity is lower in wolverines in the contiguous U.S. as compared to Canada and Alaska. We also need to determine whether there is a threat for inbreeding depression based on small population size. In addition to informing these points, knowledge gained through a more thorough and complete analysis of the genetic structure of wolverine populations throughout North America would better inform our DPS determination.

NEXT STEPS

We plan to present the final SSA Report, with peer and partner review incorporated, to the RD and decision team by December 2017.

ATTACHMENTS

See attached for a schedule outlining steps and timelines for preparation of the North American wolverine SSA Report and listing decision documents.

NOTE TO REVIEWER (NTR)

DATE SUBMITTED: June 12, 2017

PREPARED BY: Justin Shoemaker, Classification Biologist, for Mike Thabault

SUBJECT: BRIEFING MEMORANDUM ON THE NORTH AMERICAN WOLVERINE FOR THE REGIONAL DIRECTOR

CRITICAL DATES (if any)**: June 15, 2017, In-Person Briefing**

DESCRIPTION/MAIN MESSAGE:

- **THE BRIEFING MEMORANDUM IS TO INFORM THE REGIONAL DIRECTOR OF THE PROGRESS MADE ON THE NORTH AMERICAN WOLVERINE SPECIES STATUS ASSESSMENT REPORT AND THE KEY INFORMATION THAT WILL BE OF INTEREST TO THE WOLVERINE LISTING DECISION.**
- **AN IN-PERSON BRIEFING IS SCHEDULED FOR JUNE 15, 2017 AT 1PM (MST).**
- **BRIEFING TOPICS INCLUDE: UPDATED CURRENT RANGE OF THE SPECIES, TRAPPING DATA IN CANADA, NOAA/CU SNOW PERSISTENCE MODEL, NEW DENNING INFORMATION, POPULATION VIABILITY ANALYSIS AND GENETICS**

Wolverine Listing Determination Timeline
6/12/17 version

Task	Responsible Parties	Dates	Length of time
Species Status Assessment (SSA) Phase			
FR notice opening comment period on 2013 proposed listing rule	MTFO	Oct 18 2016	done
DIP letters sent out to States and partners	MTFO	Oct	done
Public comment period, input from States, partners, etc.		Oct 18-Nov 17	30 days, done
Conduct science analysis (SSA)	SSA core team	By Sept 15 2017	in process
Draft SSA report	Betty Grizzle (FO Lead Bio)	By Oct 7	in process
SSA core team meeting in Denver	Core team, R6 management and decision support staff	Feb 15-16	2 days, done
SSA report check-in w/ RD	SSA core team, management	June 8	1 hr briefing
Peer review planning and contracting	Justin Shoemaker (ULT lead), Caitlin Snyder (ULT assist)	Aug - Oct	2 months to get contracted peer reviewers in place
SSA report core team review	SSA core team	Oct 7-14	1 week
Edit SSA report based on core team review	Betty Grizzle	Oct 14-Oct 21	1 week
SSA report to peer reviewers and partners*	Justin Shoemaker, Jodi Bush (MTFO Project Leader)	Oct 21-Nov 21	1 month
Edit and finalize SSA report	Betty Grizzle	Nov 21-Dec 19	4 weeks
Listing Decision Analysis Phase			
SSA report to recommendation team	Justin Shoemaker, Jodi Bush	Dec 19	At least 2 weeks prior to recommendation team meeting
Decision meeting	RDs or delegates, ARDs, other management, SSA core team	First or second week of Jan **2018**	2 days
Draft decision summary for the record or certify decision meeting notes	R6 RD or delegate	early Jan	3 days (after recommendation team meeting)
Process for final withdrawal of proposed listing (if decision is to not list) - or revised proposed listing rule (if decision is to list)			
Draft final withdrawal (not-warranted) FR notice or revised proposed listing rule (and if necessary, proposed 10(j), 4(d))	Justin Shoemaker and Betty Grizzle	Jan 15-Feb 12	4 weeks
Core team reviews FR notice,	SSA core team,	Feb 12-Feb 26	2 weeks

*Includes States, Tribes, Federal Agencies

make revisions	Justin Shoemaker		
Regional Office Surnames and concurrence	Marjorie Nelson, Mike Thabault, Matt Hogan, Noreen Walsh, and concurring regional RDs/ARDs or delegates	Feb 26-March 12	2 weeks
SOL surname	DOI SOL	Feb 26-March 12	2 weeks
PPM	PPM	Feb 26-March 12	2 weeks
Revise based on RO/SOL/PPM comments	Justin Shoemaker and Betty Grizzle	March 12-March 21	10 days
HQ review	Sarah Quamme, Bridget Fahey	March 21-	2 weeks (submit 6 weeks prior to FR submittal date)
Asst. Director for ES Surname	Asst. Director for ES	April 4	5 business days
FWS Director Surname	Director of FWS	April 11	5 business days
Fish, Wildlife, and Parks Surname	FWP	April 18	10 business days
Executive Secretary Surname	Executive Secretary's Office	May 2	3 business days
Deliver to FR	HQ	May 7	
Publication of withdrawal or proposed rule	Federal Register	May 14	
Public comment period on revised proposed listing (only if decision is to list)		May 14-June 12	30 days (may need to be 60 days, if so will revise)
Process for final listing Federal Register document			
Comment and response strategy meeting – develop plan to review and address comments received	SSA core team, management	Mid May (TBD)	half day
Review and address public comments on proposed listing	SSA core team, support staffing as needed from R6 RO	June 12-July 16	1 month
Meeting with decision team to discuss public comment and any new info, revisit decision	Marjorie Nelson, Mike Thabault, Matt Hogan, Noreen Walsh, and concurring regional RDs/ARDs or delegates	Early July 2018	half day
Draft final listing FR doc (if necessary 10(j), 4(d))	Justin Shoemaker and Betty Grizzle	by July 16	2 months from proposed listing publication
SSA core team reviews FR notice, make revisions	SSA core team	July 16-July 23	1 week
Regional Office Surnames and concurrence	Marjorie Nelson, Mike Thabault, Matt Hogan, Noreen Walsh, and	July 23-Aug 6	2 weeks

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	concurring regional RDs/ARDs or delegates		
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PPM	PPM	July 23-Aug 6	2 weeks
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FWS Director Signature	Director of FWS	Aug 28	5 business days
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Executive Secretary Surname	Executive Secretary's Office	Sep 19	3 business days
Deliver to FR	HQ	Sep 24	
Publication of final rule	Federal Register	Sep 28, 2018	Note: We've committed to final rule in FY 18 in the work plan

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* **F** -- surname **G** -- signature **H** -- return to originating office

FROM: Trina Vigil **DATE:** 6/12/17

SURNAME		
TITLE	NAME	DATE
FIELD OFFICE		
AUTHOR Justin Shoemaker	[signature]	6/12/17
FIELD OFFICE SUPERVISOR/PL		
FIELD OFFICE ADMIN ASSISTANT / FIELD OFFICE ADMINISTRATIVE OFFICER		
REGIONAL OFFICE		
AUTHOR / RO LEAD		
SECRETARY	[initials]	6/12/17
ARD- SCIENCE APPLICATIONS		
ARD – ECOLOGICAL SERVICES		
DARD-ECOLOGICAL SERVICES		
ARD – EXTERNAL AFFAIRS		
ARD – FISHERIES		
ARD – LAW ENFORCEMENT		
ARD – MIGRATORY BIRDS		
ARD – NATL WILDLIFE REFUGE SYSTEM		
ARD- BUDGET/ADMINISTRATION		
CHIEF OF STAFF/RD OFFICE		
SECRETARY / REGIONAL DIRECTOR		
DEPUTY REGIONAL DIRECTOR		
REGIONAL DIRECTOR		
ECOLOGICAL SERVICE REGIONAL OFFICE		
BRANCH CHIEF, CLASSIFICATION AND RECOVERY	[signature]	6/12/17
BRANCH CHIEF, LANDSCAPE CONSERVATION AND RESTORATION		
BRANCH CHIEF, DECISION SUPPORT		
DIVISION CHIEF, ECOLOGICAL SERVICES		
DISTRIBUTED (FED EX) (USPS) CIRCLE ONE		

From:	Trina Vigil
To:	John Guinotte
Cc:	Annette Naylon; Justin Shoemaker
Subject:	FW: Wolverine BP
Date:	Tuesday, June 13, 2017 10:27:53 AM

FYI

Trina Vigil
Administrative Support Assistant
134 Union Blvd
Lakewood, CO 80228
(303) 236-4253

From: Stephanie Potter [mailto:stephanie_potter@fws.gov]
Sent: Tuesday, June 13, 2017 10:27 AM
To: Trina Vigil; Annette Naylon
Subject: Wolverine BP

FYI –

I moved the Wolverine BP to Steve Torbit to review before we pass it to the RD/DRD.

Stephanie Potter
Executive Assistant
Office of the Regional Director
Mountain-Prairie Region
U.S. Fish and Wildlife Service
303-236-7920

From:	A J
To:	Grizzle, Betty
Subject:	Re: Article on measuring snowpack
Date:	Tuesday, June 13, 2017 11:13:59 AM

I will try to find the report that had dens and the snow model even though it is out of date now

Sent from my iPhone

On Jun 13, 2017, at 8:58 AM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:

> I will try again to reach out to Malin, but she did not respond to my life expectancy question that I sent last month.
>
> On Mon, Jun 12, 2017 at 9:49 AM, A J <222wsheridan@gmail.com> wrote:
>
>> I have seen an older map she prepared awhile ago in one of her reports but I haven't seen any recent version with all the more recent dens. I'm fairly certain Jens or Malin could produce this but my understanding from Jens was that you did not think you could use anything that has not been published. Perhaps a quick request to Jens would answer the question, preferably well before July when all of Sweden goes on holiday and emails go unanswered!
>>
>> Sent from my iPhone
>>
>> On Jun 12, 2017, at 8:22 AM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
>>
>>> Thanks for your input on this.
>>> I'm not able to share an exact date with you for the Species Status Assessment Report, but, according to our national workplan, we are required to submit a FR document (i.e., proposed rule) early next year.
>>>
>>> A quick question - Has Jens or Malin prepared a map of their den locations relative to the predictions from Copeland et al.'s snow model? I am not recalling one at the moment, but have been out of the office for the past 10 days (attending UC Berkeley class) so I need to go back through the papers that Malin sent.
>>>
>>> On Mon, Jun 12, 2017 at 9:05 AM, A J <222wsheridan@gmail.com> wrote:
>>>
>>>> Thanks, Betty. I read the original paper a little while ago. It's exciting stuff for those interested in snow and climate change but I think it will be quite a while before snow data from this technology will be available for wolverine researchers. We looked into LIDAR for our snowdrift work on the North Slope of Alaska but the problems with scale and cost were not encouraging. For now we will stick with aerial photography in known wolverine home ranges. We photographed about 20 areas this spring on May 28/29 where snow holes were used by

wolverines and we have cameras monitoring them. Spring was at least two weeks later than last year, so lots of snowdrifts remaining. By the way, Jens went out and photographed 8 or 9 wolverine dens in southern Sweden on May 16 to document structure (no snow present). I'm hoping researchers will begin to focus on just what happens to females and kits when snow begins to melt and into the following months when kits are still left at rendezvous sites.

I've been wondering if there is a date set for when USFWS will produce the status review and decision? Just curious.
Audrey

Sent from my iPhone

> On Jun 12, 2017, at 7:10 AM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
>
> Hi Audrey - I thought you might be interested in this article from yesterday's LA Times.
>
> --
>
> Betty J. Grizzle, D.Env.
> Fish and Wildlife Biologist
> U.S. Fish and Wildlife Service
> Carlsbad Fish and Wildlife Office
> 2177 Salk Ave, Suite 250
> Carlsbad, CA 92008
> 760-431-9440, ext. 215
> 760-431-5901 fax
> <Serna_LA Times Surveying snowpack _June 11 2017.pdf>

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Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
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760-431-9440, ext. 215
760-431-5901 fax

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U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

From:	A J
To:	Grizzle, Betty
Subject:	Fwd: Next report...
Date:	Tuesday, June 13, 2017 12:06:45 PM
Attachments:	Slutgiltig_120311.docx

This is an old email from Malin where she discusses the spread of wolverines including outside the Copeland model but she doesn't present the data on top of the snow model map but rather says the red line closely matches the snow model. I sent this email and report in during the last status report review. I know Malin has the copeland snow model and I believe I have seen it with the dens but just can't recall where that is.

---------- Forwarded message ----------
From: **Malin Aronsson** <malin.aronsson@slu.se>
Date: Mon, Mar 25, 2013 at 9:31 AM
Subject: Next report...
To: "amagoun@ptialaska.net" <amagoun@ptialaska.net>, "222wsheridan@gmail.com" <222wsheridan@gmail.com>

I send you the word version of Aronsson & Persson 2012, the file is smaller so I hope you´ll get it.

Hi Audrey,

There are den sites found outside of "the snow model" during the last years. Every year there is an extensive search for wolverine dens within the reindeer husbandry area (northern half of Sweden) because the number of den sites is the base for the compensation payment system to the reindeer herders for damages caused by wolverines and the den inventory are also the basis for the population estimation. This den-site inventory has been going on since 1996. I attached to reports (both in Swedish unfortunately) that show the distribution of wolverine den sites in Sweden (we usually report den sites over a three year period because of the varying reproductive success for females). The first document (Persson and Broseth) reports the population development 1996 – 2010 and you find the den sites (with a 20 km buffer zone) in figure 1a-e. The red colour just means that there are more den sites within the buffer zones. The second document (Aronsson and Persson) is a report where we try to summarise the information we have about wolverines in the "forest areas" outside of "traditional wolverine area" (mountains and forest close to the mountains). Figure 2 shows the documented den sites (from the national inventory) with a 20 km buffer zone (blue). The red line is our definition of the limit for "traditional wolverine areas" based on land use, vegetation, the mountain range and reindeer herding practices. We classify the den sites found to the east of that line as being outside of traditional wolverine areas. Our red line matches "the snow model" pretty well in the southern half of the Swedish wolverine distribution and if you compare Copelands paper with the maps in the two reports you can see that there area quite a few den sites outside of the snow model in resent years. The blue triangles in figure 3 shows the number of documented den sites east of our red line, most of these den sites are found the southern half of the wolverine distribution and hence outside of the snow model. From 2008 and to today 12-15% of the den sites have been found east of the red line (10-18/year and it looks like a majority of those are outside of the snow model, in the area where it says "Sweden" in figure 4 in Copelands paper). But still a majority of the total den sites (90-110/year) are found inside the snow model. As for distances den sites are found from just outside the snow model to approximately 140 km outside of the snow model (rough estimates because I don´t have a GIS layer of the snow model).

We have not captured any wolverines yet ☹. But they have visited the traps a couple of times so we area still hoping. We finished setting up 6 camera stations last week and they will be on until we get back from fieldwork in the north in the end of April. So far I have some photos of one big wolverine (think it is a male). He has spots on the right side of his chest and photos I have got from local people shows that he has been in the area since at least 2010. We are at a carnivore conference in Sweden right now and there area lots of participants from the County Administrative Boards (that manages wildlife in Sweden) and I have to tell you that you have a fan club here from the field personnel from the County Administrative Boards. Some of them have your book and have tried your camera-stations on their own. We had a meeting yesterday to try to coordinate the use of camera-stations in 2 counties and today Jens said that one more county wants to join.

/Malin

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Malin Aronsson
Grimsö forskningsstation / Grimsö Wildlife Research Station
Institutionen för ecology / Dept. of Ecology
Sveriges lantbruksuniversitet / Swedish University of Agricultural Sciences
SE-730 91 Riddarhyttan
Sweden

+46 (0) 581-697312

****
Malin Aronsson
Grimsö forskningsstation / Grimsö Wildlife Research Station
Institutionen för ecology / Dept. of Ecology
Sveriges lantbruksuniversitet / Swedish University of Agricultural Sciences
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Sweden

+46 (0) 581-697312

Sammanfattning

De senaste åren har den skandinaviska järvstammen ökat i både storlek och utbredning. Data på både dokumenterade föryngringar och observationer visar att den svenska delen av järvstammen har expanderat öster och söderut från kärnområdena i fjällkedjan. Detta har fått till följd att järven numera återfinns i skogslandskap där den för bara 10 år sedan var ovanlig eller inte förekommande. Målsättningen med denna rapport är att beskriva utvecklingen av järvpopulationen i skogslandet, utanför det som ofta ses som järvens traditionella utbredningsområde i fjäll- och fjällnära skogar. För att definiera en västlig gräns för det område vi i denna rapport kallar skogslandet har vi använt odlingsgränsen och renskötselområdets åretruntmarker.

Genom en kombination av länsstyrelsens inventeringsresultat och erfarenheter från fältpersonal kan järvstammens utveckling i skogslandet beskrivas enligt följande. I Norrbotten har föryngringar har registrerats i skogslandet sedan 1997. I Västerbotten har järvstammen de senaste 5-10 åren expanderat österut från fjällen in i skogslandet, framförallt i södra delarna av länet. Den största ökningen av järvar i skogslandet har skett i Jämtlands län, framförallt söder om E14 där järvstammen är tätast i ett bälte från fjällen ner till gränsen mot Västernorrland och Gävleborg. I Västernorrland och Gävleborg dokumenterades järvetablering redan på 1990-talet. I dagsläget har järven ett starkt fäste i södra Västernorrland och norra Gävleborg. Även i norra delen av Västernorrland har järv förekommit sedan 90-talet, men betydligt glesare än i södra länsdelen. I Gävleborg är tätheten av järv högst i norra tredjedelen av länet och minskar succesivt söderut. Även i Dalarna har antalet järvar ökat. Inom renskötselområdet i nordvästra Dalarnas har det funnits en etablerad järvstam och föryngringar har dokumenterats under lång tid, medan förekomsten i övriga delar av länet främst rört sig om enstaka vandrande järvar. De senaste åren har observationer av järvspår ökat i stora delar av Dalarna. Även i norra Värmland har järvobservationerna ökat senaste åren, även om det fortfarande sannolikt rör sig om ett litet antal individer.

De flesta lyor som dokumenterats i skogslandet påträffas i stenholster, men även trädlågor och klippbranter används som lyplatser. Lyorna är oftast belägna i svårtillgängliga, ofta branta och klippiga områden på högre höjd med mer snö än omgivande landskap. Men det finns undantag där lyor har påträffats i flack terräng vid enstaka stenblock. Det är inte ovanligt att lyplatser är förlagda i närheten till förutsägbara födokällor såsom t.ex. slaktgropar. När det gäller järvens födoval i skogslandet dominerar ren och älg, åtminstone vintertid. I områden med ren är de en viktig födoresurs i form av både kadaver och renar som järven dödar själv. Älg i form av slaktrester från älgjakten och kadaver tycks utgöra en viktig födoresurs inom hela järvens utbredningsområde. Utöver ren och älg har det gjorts sparsamt med observationer av olika födoslag som järven utnyttjat. De arter som oftast påträffats är skogsfågel, hare och bäver. Att järvar tagit smågnagare dokumenteras sällan på snö, men många har sett att järvar grävt i snön på ett sätt som kan tolkas som jakt efter smågnagare. Även rester av räv och rådjur har påträffats i spår efter järv eller vid lyplatser.

En faktor som har stor påverkan på utvecklingen av antalet järvar i skogslandet är naturligtvis vad som händer med järvstammen i övriga delar av utbredningsområdet. Om populationen i källområdena ökar leder det sannolikt till att fler unga djur utvandrar därifrån och söker revir i skogslandet. En annan faktor som naturligtvis har betydelse är födotillgången. Födotillgången för järvar i skogslandet påverkas troligen främst av tillgången på ren och älg. Hur mycket av dessa djur som i sin tur blir tillgänglig som föda för järvarna kan påverkas av förekomsten av andra rovdjur, inklusive människan. Älgjakten bidrar med föda i form av slaktrester, vargar lämnar efter sig älgkadaver och lodjur lämnar renkadaver som järvar kan utnyttja. Slutligen kan man tänka sig att tillgången på lämpliga lyplatser och ett varaktigt snötäcke kan påverka järvarnas reproduktionsframgång i skogslandet. De faktorer som fältpersonal oftast anger som förklaring till att järvstammen ökat i stora delar av skogslandet är invandring från andra områden, samt att slaktavfall från älgjakten tillsammans med en ökad kadavertillgång till följd av en ökad vargstam leder till att födotillgången i många områden är god.

När det gäller järvstammens status är kunskapen relativt god inom renskötselområdet, men utanför renskötselområdet är kunskapen sämre. Inventeringsinsats och metodik varierar också över tid och mellan områden. I renskötselområdet görs årligen stora insatser för att dokumentera föryngringar. Utanför renskötselområdet är inventeringen i de flesta områden begränsad till registrering av järvspår som observeras i samband med inventering av varg och lodjur och i viss mån insamling av spillning för DNA-analys. Eftersom förvaltningen av rovdjur i Sverige är relaterad till mål för stammarnas totala storlek bör kunskap om järvstammen även utanför renskötselområdet vara relevant för förvaltningen av järvstammen inom renskötselområdet. För att få bättre kunskap om järvstammens status utanför renskötselområdet krävs inventeringspersonal som ges tid och resurser att inventera järv. En välorganiserad och intensivare insamling av spillning för DNA-analyser kan ge mer kunskap om järvstammens storlek och förekomst av föryngringar

När det gäller järvar i skogslandet har vi lite kunskap om grundläggande ekologi och i vilken utsträckning det går att överföra den kunskap vi har från forskningen i fjällområdet. Kunskap som ofta efterfrågas kring järvar i skogslandet handlar dels om grundläggande ekologi såsom hemområdesstorlek, reproduktion, dödlighet, födoval och predation på ren, men även om mer specifika kunskaper såsom födelsedatum, järvhonors val av lyplats, rörelsemönster och störningskänslighet under lyperioden. Men den kanske vanligaste frågan är vad som händer med järvstammen i skogslandet. Förhoppningsvis har vi med denna rapport bidragit till ökad kunskap om järvstammen spridning och hur järven lever i skogslandet.

Innehåll

1 Inledning

Under lång tid har järven i Sverige betraktats som en art knuten till fjällkedjan och de fjällnära skogarna. Under lång tid har den svenska delen av den skandinaviska järvpopulationen haft huvuddelen av sin utbredning i renskötselområdet längs fjällkedjan och i fjällnära skogar, från Treriksröset ner till nordvästra Dalarna (Persson & Brøseth 2011). Generellt blir populationen glesare från norr till söder även om tätheten varierar lokalt inom de olika länen. Om vi ser till registrerade föryngringar av järv är tätheten högst från Norrbottens västra delar ner till sydvästra Västerbotten, samt söder om E14 i Jämtlands län.

De senaste åren har det allt oftare uppmärksammats att antalet järvar ökat i skogslandet utanför järvens traditionella utbredning i fjäll- och fjällnära områden. Detta är en bild som framgår av inventeringsresultaten, samt är en vanlig uppfattning bland spårningspersonal i skogsområden i Västerbottens, Jämtlands, Västernorrlands, Gävleborgs och Dalarnas län (Intervjuer 2012). Samtidigt som mycket talar för att det skett en ökning av antalet järvar i skogslandet har vi lite kunskap om hur utvecklingen verkligen ser ut och hur järvarna lever i dessa områden. En stor del av den kunskap vi har om järvens ekologi kommer från forskning i Norrbottens fjällvärld. Vår målsättning med denna rapport är att med hjälp av tillgänglig information beskriva utvecklingen av järvpopulationen i skogslandet, utanför det som ofta ses som järvens traditionella utbredningsområde i fjäll- och fjällnära skogar. Vi ska också sammanställa befintlig information om järvarnas ekologi i dessa områden.

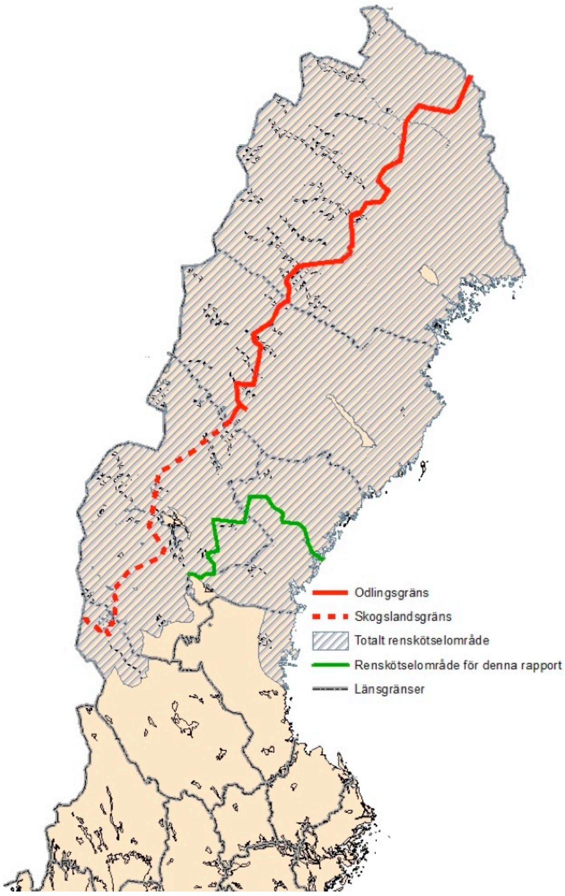
Denna rapport är finansierad av Världsnaturfonden, WWF. Tolkningar och eventuella åsikter i denna rapport är författarnas och representerar inte nödvändigtvis Världsnaturfondens.

2 Definition av skogslandet för denna rapport

Begreppet ”skogsjärvar” har under de senaste åren blivit allt vanligare. Även om det under lång tid har dokumenterats förekomst av både järvar och lyplatser i skogarna längs fjällkedjan i Sverige (Persson & Brøseth 2011). Även internationellt förknippas järven ofta främst med fjäll- och bergsområden, trots att boreala skogar utgör en betydande del av järvens utbredningsområde både i Nordamerika, Europa och Asien (Banci 1994; Pasitschniak-Arts & Larivière 1995; Slough 2007). Det är alltså inget nytt eller anmärkningsvärt att järv återfinns i skogsland långt från fjällområden, även om en stor del av kunskapen om järven kommer från fjäll- och bergsområden världen över.

Vårt syfte med denna rapport är att kartlägga järvstammens utveckling och ekologi i områden utanför fjällkedjan och de fjällnära skogarna, dvs. områden som tidigare inte ansetts ingå i järvens traditionella utbredningsområde i Sverige. För att definiera skogslandet i denna rapport har vi använt oss av odlingsgränsen och renskötselns åretruntmarker (figur 1). När vi härefter använder begreppet skogslandet avser vi området öster om odlingsgränsen (heldragen röd linje i figur 1) när det gäller Norrbotten och Västerbotten (detsamma som utanför renskötselns åretruntmarker i de flesta fjällsamebyar). I Jämtland finns det inte en lika tydlig skiljelinje. Därför har vi här förbundit åretruntmarkernas östligaste delar med odlingsgränsen för att avgränsa skogslandet (streckad röd linje i figur 1). I Dalarna sammanfaller vår gräns med renskötselns åretruntmarker. När vi fortsättningsvis skriver om järvstammen i skogslandet handlar det alltså om järvar öster om odlingsgränsen och skogslandsgränsen i figur 1. Trots att det i viss mån kan ses som artificiellt att utesluta järvar i skogsområden längs fjällkedjan använder vi oss av den ovan definierade gränsen i denna rapport. Anledningen är att vi antar att järvar ovanför odlingsgränsen generellt har mer regelbunden tillgång till ren (dvs. i åretruntmarker) och att vi med marginal vill exkludera järvar som berörs av fjällmiljön. Dessutom avgränsar det vår rapport till den del av järvstammen som varit föremål för ett särskilt intresse under senare år, utanför de traditionella järvmarkerna, de så kallade skogsjärvarna.

Situationen avseende järvarnas födoval och födotillgång är sannolikt annorlunda i och utanför renskötselområdet, vilket även påverkar järvarnas relation till mänskliga intressen. Därför har vi i denna rapport även valt att dela upp järvstammen i skogslandet i den del som förekommer inom respektive utanför renskötselområdet. Här har vi inte använt det område som formellt räknas som renskötselområde (streckat fält i figur 1) utan exkluderat Gävleborgs och delar av Västernorrlands län som inte regelbundet används som betesmarker för renar (grön gräns i figur 1). När vi i denna rapport beskriver järvstammen i skogslandet innanför respektive utanför renskötselområdet använder vi alltså denna avgränsning. Vi har valt denna gräns för att definiera renskötselområdet ur järvens perspektiv, alltså förekomst av ren. Vi vill dock poängtera att det under vissa år förekommer ren även öster och söder om denna gräns.



Figur 1. Skogslandet definieras i denna rapport som området öster och söder om den röda linjen (heldragen linje sammanfaller med odlingsgränsen). Streckat område anger det formella renskötselområdet. Men när vi i texten relaterar till renskötselområdet exkluderar vi Gävleborgs och delar av Västernorrlands län som inte regelbundet används som betesmarker för renar (öster och söder om grön linje). Vi vill dock poängtera att det under vissa år förekommer ren även öster och söder om denna gräns.

3 Informationskällor

Denna rapport bygger på flera informationskällor. Nedan följer en sammanfattning av de informationskällor vi använt oss av.

Vi har använt de koordinater för föryngringar av järv (lyplatser) som samlats in av länsstyrelsernas personal under årliga inventeringar sedan 1996. Under perioden 1996-2002 registrerades enbart en kategori av föryngringar, men sedan 2003 har årliga järvföryngringar klassificerats som säkra eller sannolika (se avsnitt 4). I denna rapport har vi använt oss av koordinater för både säkra och sannolika föryngringar. Koordinater för föryngringar från 1996-2003 har vi fått från respektive länsstyrelse, koordinater från och med 2004 har vi hämtat från databasen Rovdjursforum. Vi vill uppmärksamma att koordinatpunkter som förekommer i kartmaterialet är förskjutna, det är därför inte möjligt att ta ut exakta koordinater för järvlyor från kartorna i denna rapport. Det är viktigt att notera att utvecklingen av antal och utbredning av föryngringar kan avspegla både en verklig förändring i populationen och en förändring i effektivitet och insats i inventeringar (Persson & Brøseth 2011). Det ligger emellertid utanför ramarna för denna rapport att kvantifiera den relativa betydelsen av dessa båda faktorer.

Sedan 2004 har länsstyrelserna registrerat koordinater för observationer av järv i databasen Rovdjursforum. Att dra slutsatser om järvstammens utveckling utifrån dessa observationer är svårt då flera faktorer bidrar till att observationer är ett osäkert redskap. Exempelvis påverkas antalet observationer av inventeringsinsatsen, vilken kan variera mellan län och mellan år. Flera observationer från samma individ kan uppfattas som fler individer. Man kan också tänka sig att förekomst av järvar missas i periferin av utbredningsområdet på grund av att de helt enkelt inte förväntas finnas där. Trots dessa osäkerheter inkluderar vi järvobservationerna i denna rapport, eftersom de har ett värde som ett grovt index på populationsförändringar och framförallt på expansion i nya områden.

Vi har även genomfört telefonintervjuer med 27 personer som spårat järv i skogslandet. Huvudsakligen inventeringspersonal på länsstyrelserna i Norrbotten, Västerbotten, Jämtland, Västernorrland, Gävleborg, Dalarna och Värmland, men även andra personer som har erfarenhet av järv och järvspårning i skogslandet. Målet med dessa intervjuer var att ta del av deras kunskap och uppfattningar om a) järvstammens utveckling, b) inventeringsmetoder och insats i olika områden, c) järvars födoval i skogslandet och d) interaktioner med andra rovdjursarter. Information från intervjuer med spårningspersonal refereras i texten som (Intervjuer 2012).

Sedan 2010 har Järvprojektet (SLU) tillsammans med länsstyrelserna i Jämtland, Västernorrland och Västerbotten i samband med barmarkskontroller kartlagt järvars lyplatser i skogsområden. Vi har använt en sammanställning av denna information från 2010-2011 för att karakterisera järvarnas val av lyplatser i skogslandet.

Information om etablerade vargrevir samt koordinaterna för dessa kommer från Skandulv och Viltskadecenter.

4 Inventering av järv i Sverige

I Sverige inventeras järvstammen huvudsakligen genom registrering av föryngringar. Föryngringar fastställs genom lokalisering av järvlyor och/eller observationer av honor med ungar eller deras spår. I Sverige har länsstyrelserna ansvar för fältarbete och länsvisa sammanställningar av registrerade föryngringar. I Sverige finns ingen nationell kvalitetskontroll av inventeringen, men resultatet av inventeringarna sammanställs på nationell nivå av Viltskadecenter (www.viltskadecenter.com). Registrerade lyor klassificeras som ”säker föryngring” (dokumentation av ungar eller spår av ungar) eller ”sannolik föryngring” (dokumentation av lyplats men inte ungar). Inventeringen genomförs i huvudsak på snöföre under perioden mars-maj. Därutöver utförs barmarkskontroller på lokaler där eventuella föryngringar har en osäker status efter snöperiodens inventeringsarbete. Vid barmarkskontroller registrerar man förekomst av kriterier (spårtecken) som tyder på att reproduktion har skett på platsen innevarande år. Uppfylls dessa kriterier klassas föryngringen som sannolik.

Länsstyrelserna registrerar även observationer av järvar och spår av järvar. I renskötselområdet har denna dokumentation betydelse för ersättningssystemet då samebyar kan ersättas för regelbunden respektive tillfällig förekomst av järv om ingen föryngring dokumenteras i samebyn.

DNA-analyser av järvspillning kan användas för att inventera antal individer i en population eller för att vid vissa tillfällen särskilja familjegrupper (Flagstad m fl. 2009). Provmaterial (främst spillning), samlas in av fältpersonal i samband med registreringar av föryngringar. Från spillning extraheras kärn-DNA och det fastställs genotyp för att identifiera individer. Alla prov som ger järvspecifikt kärn-DNA blir också könsbestämda med hjälp av två könsmarkörer. Resultaten används för att analysera populationsstorlek och -differentiering, könsfördelning, spridning och släktskap. DNA-metoden används i Sverige främst som ett komplement för att öka säkerheten i särskiljning av närliggande järvlyor, men även för identifiering av enskilda individer.

Demografiska data (ålder för första reproduktion, andelen honor som reproducerar sig varje år, könskvot etc.) från järvforskningen i kombination med antalet föryngringar från inventeringarna används för att beräkna den totala järvpopulationen (Landa m fl. 1998; Landa m fl. 2001; Persson & Brøseth 2011).

5 Järvens utbredning i Sverige ur ett historiskt perspektiv

Det finns viss information att finna om järvens tidigare utbredning i litteratur och äldre jaktstatistik. Denna information är värdefull, även om det är viktigt att notera osäkerheten när vi använder äldre källor för att förstå utbredning och förekomst av rovdjur i ett historiskt perspektiv. Även idag med ett stort antal inventerare med relativt stora resurser till sitt förfogande råder osäkerhet kring bedömningar av populationsstorlek. Därför ska historiska uppgifter användas med försiktighet. Men de kan ändå ge en förståelse av de stora dragen hos tidigare utbredning och populationsförändringar.

Det finns endast begränsad dokumentation om järvens utbredning före 1800-talet. Olaus Magnus uppgav att järven under 1500-talet förekom i de nordligaste delarna av Sverige. Enligt både Ekman (1910) och Lönnberg (1936) hade järven under 1800-talet, liksom idag, sin huvudsakliga utbredning i renskötselområdets fjäll- och skogstrakter. Även då var antalet järvar högst i Norrbotten, lägre i Västerbotten och ännu lägre i Jämtland. I Norrbotten gick den östra gränsen för utbredningen ganska nära kusten även om de flesta järvarna fanns i fjällen och de fjällnära skogarna.

Noterbart är att enligt fångststatistik från 1827-1934 fanns järven under denna period i Värmland och Dalarnas skogstrakter. Söderut fångades enstaka järvar så långt ner som i Skåne, Blekinge och Småland. Sådana fångster och observationer rörde sig sannolikt om enstaka utvandrade järvar. Under 1800-talet började dock järven försvinna från Värmland och under mitten av seklet var stammen troligen borta från Värmland. Dalarna hade en liten men fast järvstam som troligen försvann under mitten av 1800-talet. Järvens förekomst i Gävleborgs län under 1800-talet är oklar, men mycket tyder på att järvens förekomst i länet var av sporadisk natur. Enligt Ekman ansågs järven ha försvunnit från Västernorrland under början av 1900-talet, där den tidigare hade förekommit framförallt i Ångermanlands nordvästra skogs- och bergstrakter.

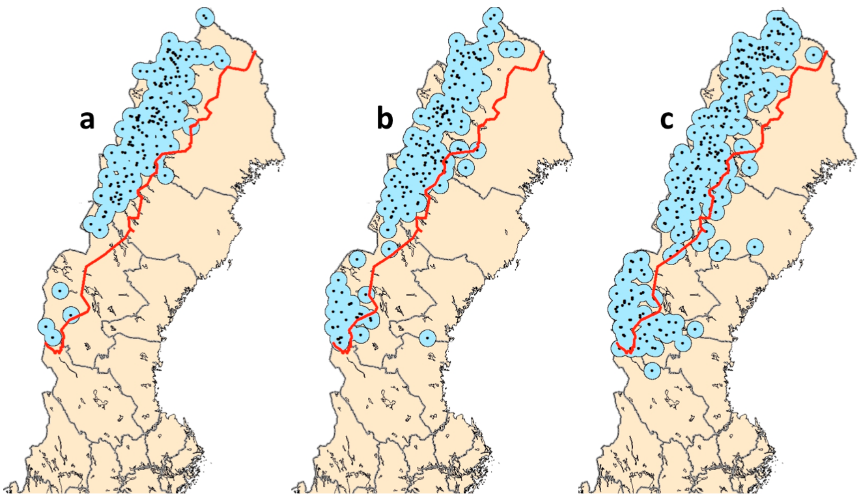
Det förefaller som att järvstammen påverkades starkt av mänsklig förföljelse redan under tidigt 1800-tal. Därför kan befintlig information om historisk utbredning underskatta järvens tidigare utbredning i söder eftersom järvens utbredning minskade från söder mot norr redan för över 200 år sedan. Vårt intryck är ändå att järvstammens utbredning i söder haft sin gräns i Värmland och Dalarna. Under 1930-talet hade sydgränsen förskjutits till mellersta Härjedalen. Det är intressant att de uppgifter som finns om järvens historiska utbredning stämmer relativt väl överens med en nutida analys av tillgång och utbredning av lämplig järvmiljö på den skandinaviska halvön (Lande m fl. 2003).

Enligt Haglund (1965) fortsatte järvstammen att minska under 1900-talet, främst till följd av ökad jakt på grund av förbättrad framkomlighet och utbetalning av skottpengar. Haglund uppskattade under 1960-talet att: ”Antalet levande järvar inom landet torde knappast överskrida etthundra exemplar. Troligen är det lägre. Det är ytterst tvivelaktigt om mer än tio kullar i hela landet går fram per år”. Under 80-talet uppskattade man att järvstammen uppgick till 120-150 individer (Bjärvall & Ullström1985). Baserat på antal föryngringar 2008-2010 beräknades den svenska järvstammen år 2010 ha uppgått till 552-790 individer.

6 Järvstammen utbredningen och utveckling i skogslandet, baserat på inventeringsresultat

6.1 Föryngringar

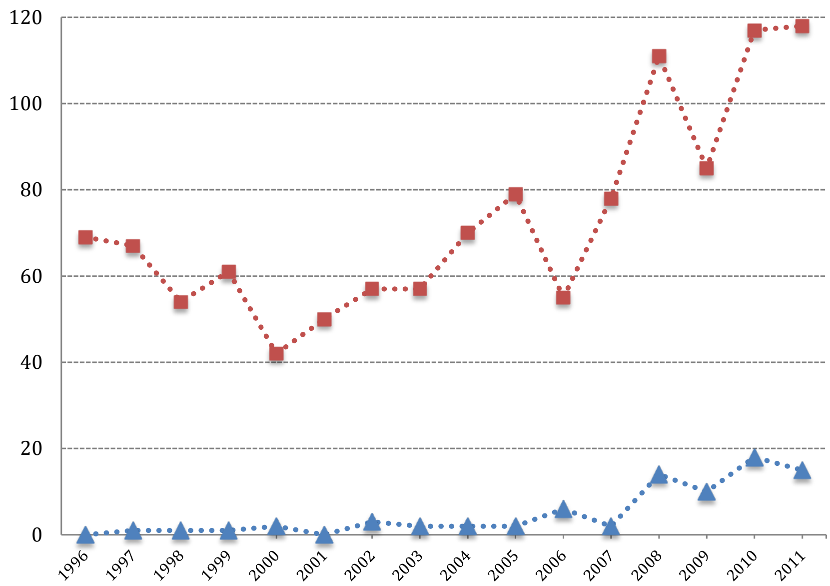
Den svenska järvstammen har ökat både i storlek och utbredning sedan den nationella inventeringen startade 1996. Denna ökning har framförallt skett i Jämtlands län (figur 2). År 2010 registrerades totalt 117 järvföryngringar (säkra och sannolika) i Sverige. Av dessa återfanns 18 (15 %) i skogslandet. År 2011 registrerades 118 föryngringar i Sverige, varav 15 (13 %) återfanns i skogslandet.



Figur 2. Karta över järvens utbredningsområde illustrerat av registrerade järvföryngringar (svarta prickar) med omgivande buffertzoner (blått; radie 20 km) för tre perioder; a) 1996-1998, b) 2004-2006, c) 2009-2011. Röd linje anger vår västliga gräns för skogslandet.

6.1.1 Föryngringar i skogslandet

Under de första inventeringsåren återfanns endast enstaka föryngringar i skogslandet. De tidigaste registrerades i Norrbotten1997-1998. Vintern 1999 registrerades den första järvföryngringen i Gävleborg. Därefter har föryngringarna i skogslandet ökat både till utbredning och antal, men det är sedan 2007 fram till idag ökningen varit mest markant. Denna ökning sammanfaller med den nationella ökningen sedan 2006 (figur 3). Från 1996-2005 utgjorde föryngringarna i skogslandet endast 0-5% av det totala antalet föryngringar i landet. År 2006 ökade denna siffra till 11 % för att nästkommande år (2007) åter minska till 3 %. Sedan 2008 fram till idag har 12-15% av de årliga föryngringarna registrerade i skogslandet.

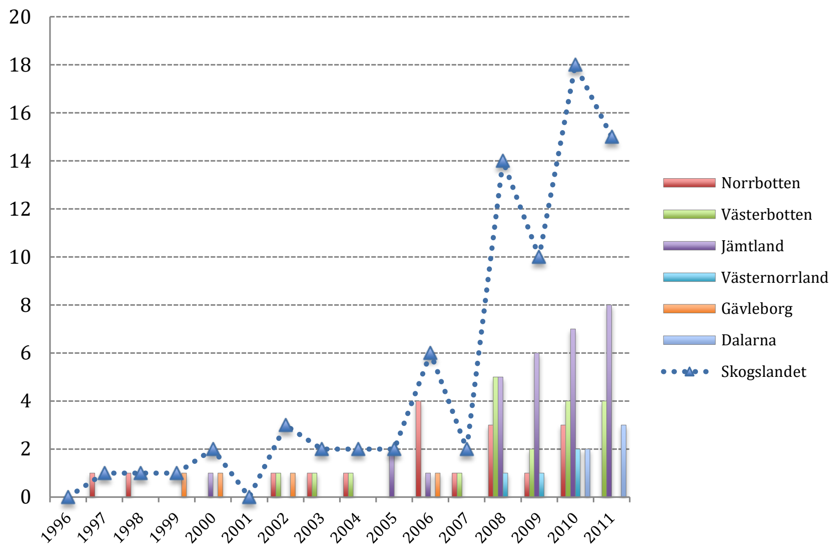


Figur 3. Totala antalet registrerade järvföryngringar (säkra och sannolika) i Sverige 1996-2011 (röda fyrkanter) samt antalet järvföryngringar registrerade i skogslandet (blåa trianglar) under samma period.

För att kunna jämföra ökningen av antalet registrerade föryngringar i skogslandet med ökningen inom järvens huvudsakliga utbredningsområde (fjällen och de fjällnära skogarna väster om vår skogslandsgräns i figur 1) behöver vi jämföra den relativa ökningstakten av antalet föryngringar. Sedan 2002 har det årligen registrerats minst 1 föryngring i skogslandet, därför jämför vi den årliga ökningen av antalet registrerade föryngringar i och utanför skogslandet under perioden 2002-2011. Den årliga relativa ökningstakten av registrerade järvföryngringar var under denna period 0,26 (*SE* ± 0,06) i skogslandet jämfört med 0,07 (SE ± 0,02) i området väster om vår gräns. Detta är en statistisk säkerställd skillnad, som visar att den relativa ökningen av antalet registrerade föryngringar varit klart högre i skogslandet jämfört med utanför ($F_{1,16}$ = 8,5; p = 0,01). Notera att ökningstakten påverkas av både reell populationsökning (reproduktion och invandring) och ökad inventeringsinsats (Persson & Brøseth 2011).

6.1.2 Föryngringar i skogslandet, länsvis

De länsvisa inventeringsresultaten visar att den största ökningen av antalet dokumenterade föryngringar i skogslandet har skett i Jämtlands län (figur 4). Den första föryngringen i Jämtlands skogsland registrerades 2000, därefter dröjde det till 2005 (n = 2) och 2006 (n = 1) innan det återigen registrerades föryngringar i Jämtlands skogsland. År 2007 registrerades ingen föryngring men därefter (2008-2011) har antalet föryngringar i Jämtlands skogsland ökat från 5 till 8 per år. Sedan 2008 fram till 2011 har 46 % av det totala antalet föryngringar i skogslandet återfunnits i Jämtlands län. Även i Västerbotten har det skett en tydlig ökning av antalet föryngrar i skogslandet (Figur 4). Åren 2002-2004 och 2007 registrerades 1 föryngring per år, men från 2008 fram till idag har man registrerat 2-5 föryngringar per år i Västerbottens skogsland. I Norrbottens skogsland har det dokumenterats 0-4 föryngringar per år sedan 1997. I norra Gävleborg registrerades en årlig föryngring 1999, 2000 och 2002. Nästa föryngring registrerades först 2006 och sedan dess har ingen ytterligare föryngring registrerats i Gävleborg. Däremot har det registrerats föryngringar i södra Västernorrlands län från 2008 och framåt. Den svenska järvstammens utbredning når i söder ner till nordvästra Dalarna om vi utgår ifrån dokumenterade föryngringar. I Dalarnas fjällområde har det dokumenterats föryngringar nästan årligen sedan inventeringen startade och de två senaste åren (2010-2011) har 2 respektive 3 av föryngringarna i Dalarna registrerats i skogslandet.



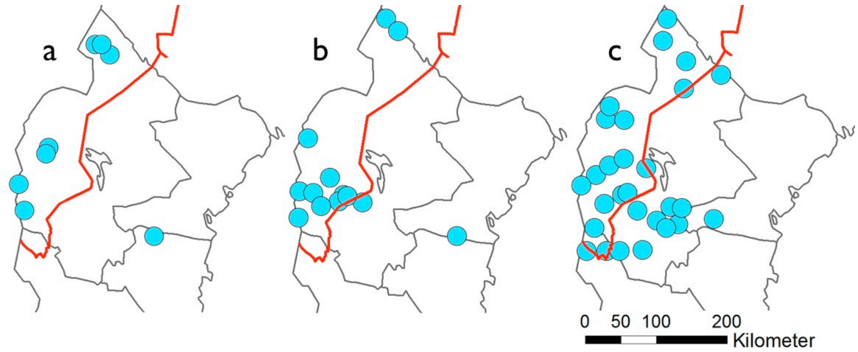
Figur 4. Totala antalet registrerade järvföryngringar (säkra och sannolika) i skogslandet 1996-2011 (blå trianglar) samt fördelningen mellan de län där föryngringarna dokumenterats.

6.1.3 De tidiga skogsjärvarna i Gävleborgs och Västernorrlands län

Begreppet ”skogsjärvar” myntades under 1990-talet när man dokumenterade att järvar etablerat sig i två områden i Gävleborgs och Västernorrlands skogsland. Det södra området var kring gränsen mellan Gävleborgs och Västernorrlands län och det nordliga i norra delen av Västernorrlands län. Under 2001-2005 studerades järvarna i dessa två områden med hjälp av DNA-analyser från insamlad spillning (Hedmark & Ellegren 2007). Under studieperioden identifierades totalt 17 olika individer i söder och 5 individer i norr. I söder ökade antalet järvar under studieperioden och 2005 identifierade man 10 olika individer i området, medan det i norr endast identifierades 2 individer detta år. Vidare visades det att den genetiska variationen bland järvarna i dessa två områden var lägre jämfört med järvarna i fjällen, vilket tyder på att dessa ”skogsjärvar” varit isolerade från järvarna i fjällen. Analyserna visade också att det troligen förekommit syskonparningar (Flagstad m fl. 2007 Hedmark & Ellegren 2007). Hedmark & Ellegren (2007) konstaterade att det behövdes invandring av järvar (nya gener) från fjällen för att säkra en långsiktig överlevnad av dessa järvar.

Inventeringsresultaten visar att det sedan 2008 har registrerats järvföryngringar i större delen av Jämtlands södra skogsland och allt tyder på vi nu har en sammanhängande järvpopulation från Jämtlandsfjällen till skogslandet i Gävleborg/Västernorrland (figur 5; Intervjuer 2012).

Det har ännu inte registrerats någon föryngring vid inventeringarna i norra Västernorrland. Enligt DNA-analyser från detta område år 2006 identifierades 6 individer varav 3 var kända sedan tidigare och 3 nyligen invandrat (Flagstad m fl. 2007), vilket visar på ett möjligt utbyte som på sikt kan stärka järvens etablering i detta område. Observationer av järv görs fortfarande i norra delen av Västernorrlands län, de är dock inte lika koncentrerade som tidigare. Däremot har det sedan 2008 årligen registrerats föryngringar strax norr om detta område, i Västerbottens län. Om detta är järvar som vandrat in från Västernorrland eller Västerbottensfjällen går däremot inte att säga utan vidare DNA-analyser.



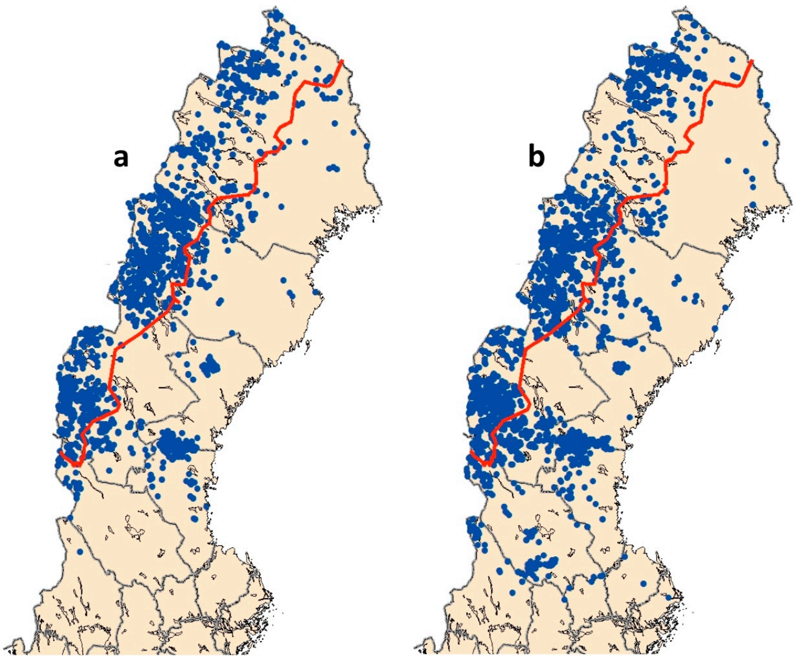
Figur 5. Utvecklingen av antalet registrerade föryngringar (blå cirklar) i Jämtlands, Västernorrlands, Gävleborgs och Dalarnas län under åren a) 1999, b) 2006 och c) 2010. Den röda linjen anger vår västliga gräns för skogslandet.

6.1.4 Järvföryngringar i skogslandet utanför renskötselområdet

I skogslandet utanför renskötselområdet har det dokumenterats en föryngring per år 1999, 2000, 2002, 2006, 2008 och 2009 samt tre föryngringar per år 2010 och 2011. Av dessa registrerades 3 föryngringar i Jämtland (2010 och 2011), 4 föryngringar i Gävleborg (1999, 2000, 2002 och 2006), 4 föryngringar i Västernorrland (2008, 2009 och 2010) och 1 föryngring i Dalarna (2011).

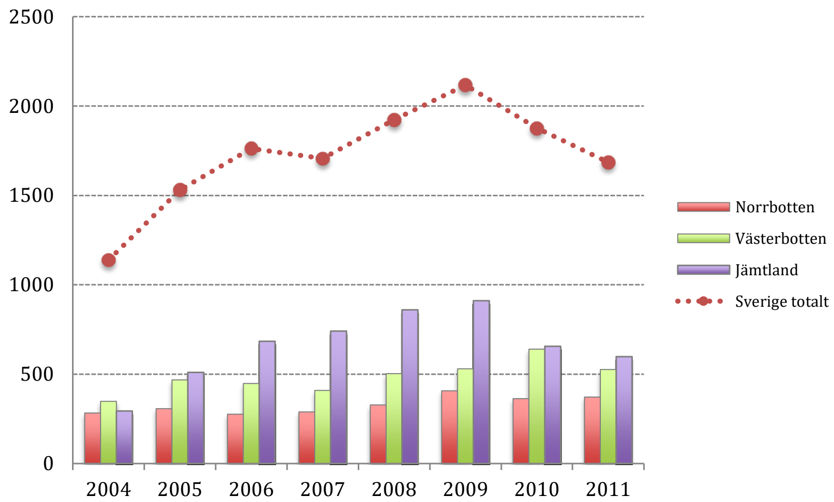
6.2 Observationer

Sedan 2004 har länsstyrelserna registrerat observationer av järv. Dessa observationer är framförallt spårobservationer (78 %), resterande är synobservationer eller observationer av lyplatser. Under 2004 registrerades totalt 1 138 järvobservationer i Sverige, 2009 hade detta antal nästan fördubblats då 2 117 observationer registrerades, för att sedan minska ner till 1 686 under 2011 (figur 6 och 7).

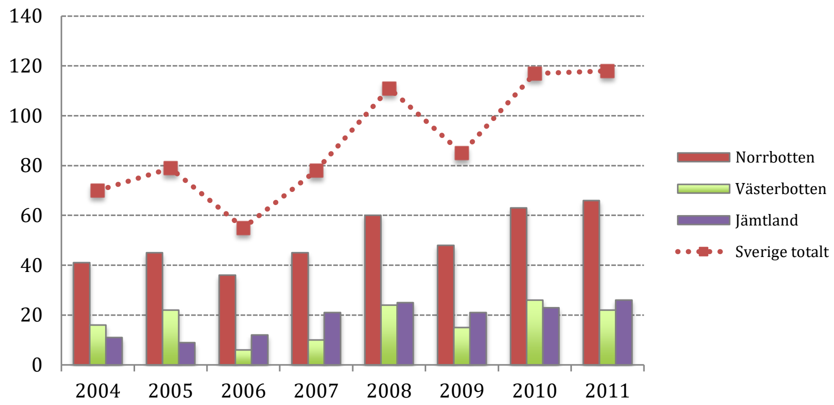


Figur 6. Karta med observationer av järvar (blå prickar) under två perioder; a) 2004-2005 och b) 2009-2010. Röd linje anger vår västliga gräns för skogslandet.

Antalet observationer är ett osäkert redskap för att dra slutsatser om järvstammens utveckling. Registrering av observationer är inget krav i järvinventeringen och antalet observationer varierar stort mellan de olika länen, en variation som inte alltid är direkt kopplat till förekomsten av järv. Exempelvis kan benägenheten att registrera spårobservationer vara högre i områden där det är glest mellan järvarna jämfört med områden med hög täthet av järv, där man fokuserar mer på att dokumentera föryngringar. Det är därför intressant att se på antalet registrerade observationer i förhållande till antalet föryngringar i olika län innan vi redovisar antalet järvobservationer i skogslandet (figur 7 och 8). År 2004 var antalet registrerade järvobservationer relativt lika i Norrbotten, Västerbotten och Jämtland trots att majoriteten av föryngringarna (58 %), och därför också antalet individer, återfanns i Norrbotten. Från 2004-2010 ökade antalet observationer i Jämtland och Västerbotten i förhållande till Norrbotten medan drygt 50 % av föryngringarna fortfarande registrerats i Norrbotten. Av observationerna 2011 registrerades 22 % i Norrbotten, 31 % i Västerbotten och 35 % i Jämtland medan fördelningen av antalet föryngringar samma år var 55 % i Norrbotten, 19 % i Västerbotten och 22 % i Jämtland.



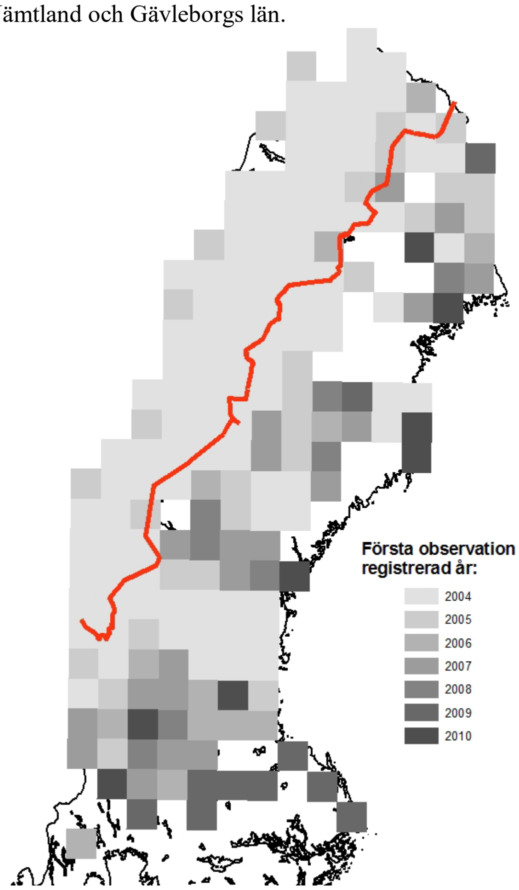
Figur 7. Totalt antal observationer (av spår, järvar och lyplatser) från 2004-2011 i Sverige (röda cirklar) samt antalet observationer i Norrbottens, Västerbottens och Jämtlands län.



Figur 8. Totalt antal dokumenterade föryngringar (säkra och sannolika) från 2004-2011 i Sverige (röda fyrkanter) samt antalet föryngringar i Norrbottens, Västerbottens och Jämtlands län.

6.2.1 Den svenska järvpopulationens expansion, baserat på observationer.

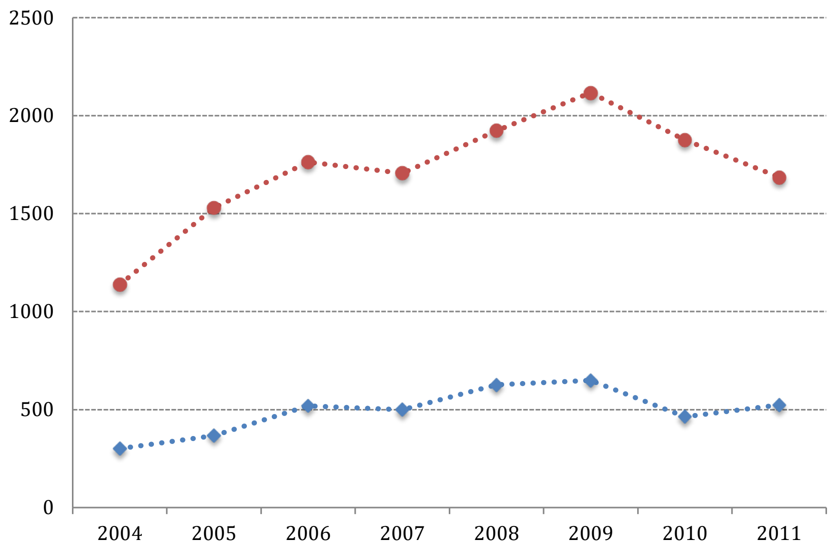
Trots ovan nämnda osäkerheter kan observationerna av järv användas som ett grovt index på populationsförändringar och expansion in i nya områden.
För att illustrera eventuella förändringar i utbredningen av observationerna sedan de började registreras 2004 har vi delat upp Sverige i ett rutnät där rutorna mäter 20*20 km (figur 9). För varje år har vi sedan markerat alla rutor som innehåller en eller flera observationer av järv det året. Detta ger oss en bild av hur utbredningen av observationer har ändrats över tid, oberoende av antalet observationer inom samma område. I figuren redovisar vi rutorna med registrerade observationer över hela Sverige. För år 2004 visas alla rutor som hade järvobservationer det året (ljusa), därefter visas enbart de rutor som tillkommit under respektive år, rutorna blir mörkare ju senare de tillkommit. I figuren ser vi att utbredningen av observationer från 2004 till 2010 har ökat i två riktningar, från fjällkedjan österut mot kusten och söderut från Jämtland och Gävleborgs län.



Figur 9. Järvpopulationens expansion i Sverige 2004 till 2010 baserat på observationer. Varje ruta mäter 20*20 km. Rutorna har fått en färg beroende på vilket år den första järvobservationen registrerades inom respektive ruta. För år 2004 visas alla rutor där järv observerades det året (ljusa), därefter visas enbart de rutor där observationer tillkommit under respektive år fram till 2010. Mörkare färger betyder att järv observerades senare i rutan.

6.2.2 Observationer av järv i skogslandet

Precis som antalet observationer på nationell nivå har antalet observationer av järv i skogslandet fördubblats från 2004 till 2009 för att sedan sjunka något 2010 och 2011 (Figur 10). Det registrerades 301 observationer i skogslandet 2004. Flest observationer registrerades 2009 (n = 649). Däremot har inte andelen av observationerna på nationell nivå som registrerats i skogslandet ökat under denna period, det har sedan 2004 rört sig om 24-33% av det totala antalet observationer. Att vi inte ser samma ökning av andelen observationer som registrerats i skogslandet som i andelen föryngringar i skogslandet beror troligtvis delvis på att observationer av järv inte började registreras förrän 2004, skulle observationer av järv ha registrerats under samma period som föryngringar (sedan 1996) skulle vi troligtvis sett en ökning i andelen järvar som observerats i skogslandet.

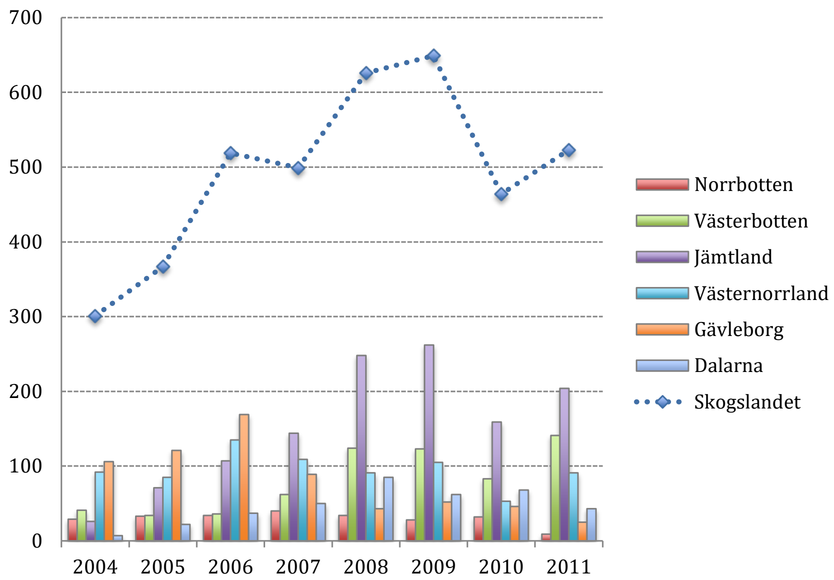


Figur 10. Antal järvobservationer från 2004-2011 totalt i landet (röda cirklar) och i skogslandet (blå diamanter).

6.2.3 Observationer i skogslandet, länsvis

Precis som för antalet dokumenterade föryngringar har den största ökningen av antalet observationer av järv i skogslandet skett i Jämtlands län (Figur 11). År 2004 registrerades endast 9 % (n = 26) av alla järvobservationer i skogslandet i Jämtlands län, 2011 registrerades 39 % av observationerna i skogslandet i Jämtlands län. Även observationerna av järv i skogslandet i Dalarna har ökat, 2004 registrerades endast 2 % (n = 7) av alla järvobservationer i skogslandet i Dalarnas län, medan samma siffra 2010 var 15 % (n = 68). Under 2011 minskade däremot antalet observationer i Dalarna ner till 8 % (n =43) av det totala antalet järvobservationer i skogslandet. I Västernorrland har det registrerats ca 100 observationer av järv per år, förutom 2010 då det endast registrerades 53 observationer. Andelen av det totala antalet observationer som registrerats i Västernorrland har däremot minskat från 31 % (2004) till 17 % (2011). Trots att det sedan 90-talet är järvarna i Gävleborg som föranlett mycket av diskussionerna kring ökande antal järvar i skogslandet har antalet observationer av järvar i Gävleborg minskat från 2004 till 2011. År 2004 registrerades 106 (35 %) av alla observationerna i skogslandet i Gävleborgs län. År 2011 hade dessa siffror sjunkit till 25 (5 %) i Gävleborg. Andelen av de totala observationerna i skogslandet har under 2004-2010 varierat från 4-10 % i Norrbottens län samt 7-20% i Västerbotten.

Förutom de län som finns representerade i figur 11 har järvar även observerats årligen i Värmland sedan 2005. Under 2009 registrerades enstaka observationer av järv i Stockholms-, Uppsala-, Västmanlands- och Örebro län. I Örebro län registrerades även observationer 2007 och 2011.



Figur 11. Totala antalet registrerade observationer av järv i skogslandet 2004-2010 (blå diamanter) samt fördelningen mellan de län där observationerna registrerats.

6.2.4 Observationer av järv utanför renskötselområdet

Utanför renskötselområdet har det mellan 2004 och 2010 registrerats 137-210 observationer av järv per år. De största förändringarna i antalet observationer utanför renskötselområdet har skett i Dalarnas- och Gävleborgs län, i de andra länen är antalet registrerade observationer relativt konstant. I Dalarnas län har observationerna utanför renskötselområdet ökat från 1 till 38 mellan 2004 och 2010. I Gävleborgs län har däremot antalet observationer utanför renskötselområdet minskat. År 2004 registrerades 106 observationer i Gävleborg, denna siffra ökade till 169 år 2006 för att sedan minska till 25 observationer år 2011.

6.3 Sammanfattning av inventeringsresultaten

Sammanfattningsvis kan vi konstatera att i takt med att den Svenska järvstammen ökat sedan 1996 har även antalet registrerade föryngringar i skogslandet ökat. Då inventeringen startade 1996 registrerades 69 föryngringar i landet varav ingen i skogslandet. Detta kan kontrasteras mot år 2010 då 18 av 117 föryngringar registrerades i skogslandet. Ökningen i antalet registrerade föryngringar i skogslandet har varit som tydligast under de senaste 4 åren (2008-2011), då föryngringarna i skogslandet stått för 12-15% av det totala antalet registrerade föryngringar i Sverige. Den största ökningen är antalet årliga föryngringar i skogslandet kan vi se i Jämtland, men även i Västerbottens skogsland har antalet ökat. Ökningen i Jämtlands skogsland har fått till följd att vi nu har en sammanhängande järvpopulation från området på gränsen mellan Gävleborg och Västernorrland, där det dokumenterats järv sedan slutet av 1990-talet, till Jämtlandsfjällen. Större delen av ökningen av reproduktioner i skogslandet har skett inom renskötselområdet.

Även antalet observationer av järv har ökat både på nationell nivå och i skogslandet. Nationellt sett har observationer av järv ökat öster och söderut från fjällkedjan sedan 2004. Antalet observationer av järv i skogslandet har ökat i framförallt Jämtland och Dalarna medan de minskat i Gävleborg och Västernorrland. Sedan 2005 har observationer av järv även registrerats i mer sydliga län, som framförallt norra Värmland men även Örebro, Västmanland, Uppland och Stockholm. Om vi utgår ifrån inventeringsresultaten sträcker sig den svenska järvstammen idag från norra Norrbotten ner till södra Dalarna och norra Värmland, och under de senaste åren har det skett en ökning i skogslandet både österut och söderut.

7 Faktorer som påverkar järvens utbredning i skogslandet

För förvaltningen av järvstammen är det viktigt att förstå vad som påverkar utbredning och antal i skogslandet. Det finns begränsat med data för att analysera detta. Istället diskuterar vi tänkbara faktorer som kan påverkar etablering och utbredning av järvar i skogslandet. Dessa faktorer är betydelsen av utvecklingen av järvpopulationen i övriga delar av Skandinavien, tillgången på bytesdjur, förekomst av andra rovdjur (varg och lodjur) samt lämpliga lyplatser och snötillgång.

7.1 Utvecklingen i tänkbara källpopulationer i svenska fjällen och södra Norge

En viktig faktor som kan påverka utvecklingen av antalet järvar i skogslandet är naturligtvis vad som händer med järvstammen i övriga delar av utbredningsområdet (ex. svenska fjällen och södra Norge). När antalet järvar i andra delar av populationen ökar är det ett resultat av hög överlevnad och/eller reproduktion. Det får till följd att populationen blir tätare i dessa områden. Det i sin tur gör att fler unga djur i större utsträckning tvingas utvandra längre för att finna lediga revir. Framförallt unga honors utvandring tycks påverkas av tillgängligheten av lediga revir i eller i närheten av uppväxtområdet (Aronsson 2009). Det innebär att när populationen ökar i fjällen och i Norge ökar sannolikheten att fler utvandrande unga djur söker revir i skogslandet. Omvänt, om populationen i källområden minskar kan man anta att utvandringen till skogslandet minskar. Den svenska järvstammen har ökat de senaste åren och tydligast har ökningen varit i Jämtland (Persson & Brøseth 2011), vilket är det län som ligger närmast till hands som källpopulation för järvar i skogslandet. Även i södra Norge har järvstammen ökat det senaste decenniet (Persson & Brøseth 2011). Ett ökande antal järvar i traditionella järvområden på den skandinaviska halvön är sannolikt en viktig orsak till att stammen expanderar in i nya områden

7.2 Födotillgång – ren och älg utgör basen

Även om järven har kapacitet att döda större bytesdjur såsom ren och i vissa sällsynta fall även älg, utnyttjar järven till stor del kadaver som födokälla. I områden med renar utgör dessa generellt den huvudsakliga födan för järven. I områden utan renar måste däremot järven förlita sig på andra födokällor såsom älg (kadaver och slaktrester), rådjur, skogsfågel, bäver, hare och smågnagare. En gemensam nämnare när det gäller järvars födoval i skogslandet, från renskötselområdet i Västerbotten ner till södra Dalarna, är att älg utgör en mycket viktig födoresurs för järvarna, åtminstone under vinterhalvåret (Kilström 2004, Intervjuer 2012). Av de älgar som järvarna utnyttjar utgörs en stor del av rester från älgjakten i form av slaktrester, ofta vid regelbundet använda slaktgropar, men även hela älgar som dött efter att ha skadeskjutits, körts på av bilar och tåg eller dött av andra orsaker. I områden med varg utnyttjar järvarna även kadaver som vargarna lämnat efter sig (Intervjuer 2012). Mängden älg som är tillgänglig för järvar och andra asätare varierar naturligtvis mellan områden beroende på älgtäthet och dödlighet i älgstammen. Wikenros (2011) beräknade att det i skogslandet i Mellansverige tillgängliggörs omkring 23-24 000 kg kött i ett område motsvarande 900 km^2, vilket kan ses som en indikation på hur mycket älgkött som kan vara tillgängligt för järvar och andra asätare i ett skogsområde.

7.3 Varg

Då järvar etablerar sig längre söderut i landet betyder det att de i större utsträckning kommer att överlappa med vargens utbredning. Förekomst av varg kan påverka järvar både positivt och negativt. Dels kan järvarna gynnas då de får tillgång till en regelbundet förekommande födokälla i form av kadaver som vargar lämnat efter sig då de dödat älgar och annat klövvilt, vilket kan ha positiv effekt på järvarnas överlevnad och reproduktionsframgång (Persson 2005). Å andra sidan händer det att vargar dödar järvar. Det har dokumenterats på flera håll i Nordamerika (Burkholder 1962, Boles 1977, Banci 1987) och i Norge dödades troligen en sändarförsedd järvhona och en av hennes ungar av vargar (Landa pers. medd.).

I en svensk studie av effekten av vargförekomst på övrig fauna fann man att vargar vanligen inte konsumerar hela älgar som de dödat, vilket innebär att det blir mat över till asätare (Wikenros 2011). Dessutom fann man att det med varg blir jämnare tillgång på kadaver över året jämfört med slaktrester som framförallt förekommer under hösten. Denna studie genomfördes framförallt söder om områden med fast etablering av järv, men man dokumenterade ändå besök av järv vid en vargdödad älg. I områden där järv och varg överlappar i större utsträckning observeras regelbundet att järvar utnyttjar vargdödade älgar (Intervjuer 2012). Det är följaktligen mycket troligt att förekomst av varg innebär en ökad och mer förutsägbar födotillgång för järvar i skogslandet utanför renskötselområdet, vilket i sin tur bör ha en positiv inverkan på järvens möjligheter att etablera och reproducera sig. Under en studie i södra Norge (van Dijk m fl. 2008) fann man att i skogsområden med varg utgjorde älg en större del av järvars diet än i övriga områden. Denna skillnad kunde inte förklaras av högre älgtäthet, istället förklarade man det med att järvarna i dessa områden utnyttjade kadaver av vargdödade älgar och att återetableringen av varg kan ha bidragit till att järvpopulationen återetablerade skogsområden i södra Norge. Dock visade samma studier att järven inte aktivt följde vargen för att utnyttja kadavren, vilket man tolkade som ett tecken på att järvarna undviker vargar. Även spårare i områden med varg och järv som regelbundet observerar att järvar utnyttjar vargdödade älgar anger att det är ovanligt att de ser att järvarna följt efter vargar, (Intervjuer 2012). Nordamerikanska studier har också visat att järv och varg inte använder samma områden (Bowman m fl. 2010) och att framförallt honor undviker områden med hög sannolikhet att träffa på vargar (Krebs m fl. 2007).

Vi har använt inventeringsresultaten för varg och järv för att beskriva utvecklingen av järvstammen i skogslandet i områden där båda arterna överlappar. I dagsläget finns det inte så många dokumenterade järvföryngringar i områden med etablerade vargrevir, eftersom det är först på senare år som vargens och järvens utbredningsområden har börjat överlappa i Sverige. Därför har vi i dagsläget inte tillräckligt underlag för att göra en kvantitativ analys av vargens betydelse för järvens etablering och/eller reproduktionsframgång. Vi har istället begränsat oss till att ge en överblick över dokumenterade järvföryngringar i relation till etablerade vargrevir. För att studera vargens påverkan på järven på en mer detaljerad nivå behövs riktade fältstudier.

I Jämtland har det enligt inventeringsresultaten registrerats tre vargrevir under en inventeringssäsong vardera (03/04, 05/06 och 07/08). Inom och runt dessa revir har det registrerats föryngringar av järv både innan, samtidigt och efter vargetableringen. I skogslandet på gränsen mellan Gävleborg och Västernorrland där den första järvföryngringen dokumenterades 1999 etablerades det första vargreviret (Grundsjön) säsongen 02/03. Sedan inventeringssäsongen 04/05 fram till idag har det funnits minst ett etablerat revir i detta område. I samma område har det registrerats järvföryngringar 1999, 2000, 2002, 2008, 2009 och 2010, majoriteten av dessa finns innanför de kända gränserna för vargreviren. I norra Dalarnas län registrerades de första järvföryngringarna utanför renskötselområdets åretruntmarker 2010 och 2011. I detta område har det funnits etablerade vargrevir 2002-2006, därefter visar inventeringsresultaten på vargetablering något söderut från detta område.

I Gävleborg och Dalarna kan vi se på observationer av järv i förhållande till etablerade vargrevir. De första åren registrerades observationer både innanför och utanför etablerade vargrevir, däremot kan vi se att under de senaste åren har järv nästan enbart observerats inom kända vargrevir. Det senare är möjligen en effekt av att länsstyrelsens inventeringar i stor utsträckning är koncentrerade till områden med vargetablering.

Det är alltså svårt att dra några tydliga slutsatser kring vargens betydelse för järven utifrån inventeringsdata. Men det är en vanlig uppfattning bland inventerare som arbetar både i och utanför vargrevir att fler järvspår observeras i än utanför vargrevir (Intervjuer 2012). Vi vet att järvar i stor utsträckning är kadaverätare och att vargar lämnar efter sig kadaver som järvarna och andra asätare kan utnyttja året om (Wikenros 2011). Det mest sannolika är att födotillgången blir bättre för järvarna i områden med varg, vilket också är en vanlig uppfattning bland spårningspersonal (Intervjuer 2012).

7.4 Lodjur

Studier i Jokkmokksfjällen har visat att järvar i stor utsträckning utnyttjar renar som dödats av lodjur (Mattisson m fl. 2011). Även bland de som spårar järv i skogslandet är det en utbredd uppfattning att järvar i hög grad utnyttjar renar som dödats av lodjur. Uppfattningen är även att lodjursdödade renar vanligen utgör en större andel av de renar som utnyttjas av järvar jämfört med ren som järven dödat själv (Intervjuer 2012). I områden med lodjur och renar bidrar alltså lodjur till en ökad tillgång på kadaver som järvar kan utnyttja. Ökad födotillgång har visat sig ha en positiv effekt på järvhonors reproduktionsframgång (Persson 2005). En logisk slutsats av detta är att lodjur sannolikt har positiv påverkan på järvars födotillgång och därmed etablering och reproduktionsframgång även i skogslandskapet inom renskötselområdet.

Utanför renskötselområdet lever lodjur främst på rådjur (Aanes m fl. 1998). Med tanke på att järvar i så hög grad utnyttjar lodjursdödade renar skulle men kunna förvänta sig att de även utnyttjar rådjurskadaver som lodjuren lämnat efter sig. Det är emellertid okänt i vilken utsträckning detta sker. Intrycket är att det i dagsläget är ovanligt, då endast en av de spårare vi intervjuat har dokumenterat detta. En bidragande orsak till detta är att i stora delar av områden med etablerade järvar är det relativt litet överlapp mellan järvar och betydande förekomst av rådjur (Intervjuer 2012). I områden där järv, lodjur och rådjur överlappar mer kan man naturligtvis förvänta sig att järvar oftare livnär sig på rådjur som lodjur dödat eller som järven dödat själv.

7.5 Lyplatser och snötillgång

I fjällen är en typisk järvlya placerad i närheten av trädgränsen, i en snödriva som bildats invid en klippkant eller i stenholster täckta med snö. I de flesta områden i de svenska fjällen är tillgången på branter och blockterräng god, liksom tillgången på snödrivor i lägen där de inte smälter förrän långt in på våren. I fjällen är lämpliga lyplatser sannolikt inte en begränsande faktor för järvhonors reproduktion. I skogen finns sällan tillgång till klippkanter med stora snödrivor utan de flesta järvhonor förlägger lyan i stenholster (se 10.1). Det förekommer även att honorna använder trädlågor, stensamlingar efter vägbyggen och andra strukturer för sin lyplats. I skogslandet kan tillgången på strukturer som lämpar sig för järvlyor variera avsevärt. Skogslandet ligger på lägre höjd än fjällen med tidigare snösmältning som följd. Ser vi på en nord-sydgradient är det naturligtvis så att tillgången på ett varaktigt snötäcke i genomsnitt är bättre i norr än i söder. I Norrbottens-, Västerbottens- och Jämtlands skogsland kan man anta att snötillgången generellt inte är en begränsande faktor för järvhonor och deras reproduktionsframgång. Situationen blir gradvis annorlunda när man ser på områden längre öster och söderut. Det är en vanlig uppfattning bland spårare att lyor i skogslandet oftast påträffas i snörika områden på hög höjd där tillgång till branter och stenholster är bättre än i omgivningen (Intervjuer 2012). Betydelsen av snö för järvars reproduktion är inte dokumenterad i detalj, men flera studier indikerar att järvens utbredning på stor skala är knuten till områden med ett varaktigt snötäcke under våren (Copeland m.fl. 2010; Aubry m.fl. 2007). Snö ger ett isolerande skydd för ungar mot låga temperaturer samt skyddar mot andra rovdjur. Det är möjligt att snö- och vinterförhållanden kan komma att påverka om och i vilken takt järvar lyckas reproducera sig i södra delarna av utbredningsområdet. Vid ett mildare klimat kan man tänka sig att den sydliga gränsen för lämpliga områden för järven kommer att förskjutas norrut.

8 Utbredningen och utveckling av järvstammen i skogslandet, baserat på intervjuer

I detta avsnitt beskriver vi järvstammens utveckling och status i skogslandet, baserat på intervjuer med 27 personer som har mångårig erfarenhet och kunskap från spårning av järv och andra rovdjur, från Värmland i söder till Norrbotten i norr.

Norrbottens län

I Norrbotten är uppfattningen att järvstammen har expanderat de senaste 5-10 åren. Järven finns här i huvudsak i fjällområden eller skogsland i närheten av fjällen. Föryngringar har registrerats i skogslandet sedan 1997. Länsstyrelsen följer utbredningen av järv i skogslandet främst genom arbetet med lodjursinventering samt genom rapporteringar från renskötare.

Västerbottens län

I Västerbotten är uppfattningen att järvstammen har ökat i skogslandet de senaste 5-10 åren. Denna uppfattning grundas främst på att det dels registrerats fler föryngringar samt att inventeringspersonalen ser fler järvspår i skogslandet. Ökningen tycks ha skett som en gradvis expansion österut från fjällområdena, den tydligaste ökningen har observerats i södra delarna av länets skogsland.

Flera faktorer anges som tänkbara orsaker till ökningen. Generellt är uppfattningen att förutsättningarna är goda för järven i Västerbottens skogsland. Orsaker för detta sägs framförallt vara god födotillgång (t.ex. lodjursdödade renar och slaktavfall från älgjakten) och att omfattningen av illegal jakt anses vara låg. En kommentar är att i vissa områden uppfattas det rentav som att födotillgången vintertid ökat i skogslandet medan den minskat i fjällen och att detta haft till följd att antalet järvar gradvis ökat i skogslandet och minskat något i fjällen. En förklaring till detta kan vara en effektivare flyttning av ren från fjället till skogen under höstvintern. Även om uppfattningen är att järvstammen ökat i skogslandet poängterar man att både inventeringsinsatsen och kunskapen om järvinventering har ökat, vilket förklarar en del av den dokumenterade ökningen. När dagens inventeringssystem infördes inventerades det mycket lite nedanför odlingsgränsen, det är först på senare tid som inventeringsinsatsen ökat i skogslandet. Samtidigt är det en generell uppfattning att man fortfarande missar föryngringar i skogslandet, dels för att det är svårt att inventera och dels för att man helt enkelt inte hinner med att söka av alla områden.

Jämtlands län

Även i Jämtland upplevs en tydlig ökning av järvstammen i skogslandet men det är tydliga skillnader i utveckling inom länet. I grova drag tycks den största ökningen skett söder om E14, i ett bälte mellan södra Jämtlandsfjällen och Härjedalsfjällen mot södra Västernorrland och norra Gävleborgs län. Här finns numera områden med hög täthet av järv (jämförbart med höga tätheter i fjällområden). Ökningen av järvstammen upplevs ha startat för 5-10 år sedan. Även söder om detta bälte tycks antalet järvar ha ökat, även om det skett senare och i mindre utsträckning. Utvecklingen här varierar, i vissa områden upplevs en fortsatt ökning medan det i andra uppfattas som att ökningen avstannat. Norr om E14 noteras fler järvspår idag jämfört med för 10 år sedan, men stammen är glesare än söderut och man har här inte registrerat någon föryngring. Järvstammen i Jämtlands skogsland söder om E14 är nu relativt tät och sammanhängande ner till västra delarna av Västernorrland och Gävleborg.

Flera faktorer anges som troliga förklaringar till ökningen i Jämtlands skogsland. En allmänt angiven förklaring är att en ökning av järvstammen i angränsande områden, både i Jämtlandsfjällen och i Västernorrland, har resulterat i ett ökat tillflöde av individer. Som en annan möjlig förklaring anges att den illegala jakten kan ha minskat både i fjällen och i skogen. En allmän uppfattning är att födotillgången för järvar är god, särskilt i de områden där älgstammen under en längre tid varit relativt tät (även om den minskat något de senaste åren). Samtidigt poängterar man även här att inventeringsinsatsen i skogslandet har ökat, vilket fått till följd att fler föryngringar registreras. Att inventeringsinsatsen ökat beror på att man insett att det finns mer järv i skogslandet än vad som tidigare antagits och att man därför tillsatt resurser för inventering i dessa områden. Men det är fortfarande så att man tror att det missas föryngringar i en del områden.

Västernorrlands län

Nordvästra Västernorrland var ett av de två första områden där fast förekomst av järv dokumenterades i skogslandet utanför traditionella järvområden. Med hjälp av DNA har man i efterhand konstaterat att det troligen skett föryngring i området (som dock inte finns med i inventeringsdata). De senaste 5 åren har det inte skett någon märkbar förändring vad gäller järvförekomst i detta område. I nordöstra delen har antalet järvar troligtvis minskat under senare år. Generellt är det glesare mellan järvar i norra delen av länet än i den södra delen. Södra delen av länet är det område där det tidigt uppdagades etablering av järv i slutet av 90-talet (se avsnitt 6.1.3). Det var främst i området mellan Ljungan och gränsen mot Jämtlands och Gävleborgs län som det tidigt dokumenterades etablering av järv. Uppfattningen är att det inte varit någon tydlig ökning av antalet järvar i kärnan av detta område de senaste åren och att det kan bero på att tätheten av etablerade djur numera är hög. Däremot är uppfattningen att antalet järvar ökat i omgivande marker norr, öster och söderut från detta område.

Commented [JP1]: Referns också

Förklaringar som anges till att järvstammen etablerat sig och fortsatt breda ut sig i länet är att det tillkommer nya individer dels via invandring västerifrån (Jämtland) och via föryngringar inom länet. Man anser sig ha relativt god kännedom om järvstammens utbredning, men att kunskapen om antal individer är dålig, bland annat på grund av problematik kring DNA-insamling. Likaså är kunskapen bristfällig vad det gäller antal föryngringar i länet. Detta beror främst på bristande tid till sökande efter föryngringar, framförallt eftersom snöförhållanden ofta blir dåliga snart efter att den prioriterade inventeringen av lodjur avslutats.

Gävleborgs län

I Gävleborgs län kan man i grova drag beskriva det som att tätheten av järv är högst i norr och minskar succesivt söderut. Norra tredjedelen av länet, norr om Ljusdal mot Jämtlands och Västernorrlands län, ingår i det område där det under slutet av 90-talet dokumenterades de första föryngringarna av järv i skogslandet utanför traditionella järvmarker (se avsnitt 6.1.3). Här har järven än idag sitt starkaste fäste i länet, och sannolikt förekommer föryngring i detta område. I mellersta tredjedelen, mellan

Ljusdal i norr och Edsbyn-Bollnäs i söder observeras järvspår regelbundet och uppfattningen är att populationen sakta sprids söderut. I södra tredjedelen av länet, söder om Edsbyn-Bollnäs, observeras däremot sällan järvspår.

Att järvstammen ökat tros bero dels på invandring från områden i norr och väster där stammen ökat, och dels på en ökad födotillgång till följd av en tät älgstam och en växande vargstam, med bättre tillgång på älgkadaver som följd samt tillgång på slaktrester efter älgjakten.En viktig aspekt vad gäller kunskapen om järvstammen i Gävleborgs län är att inventeringsinsatsen minskat och är idag mycket begränsad. I länet bedrivs ingen aktiv spårning av järv, man söker inte efter föryngringar och har inte tid att spåra för att samla in spillning för DNA-analys. Järvinventeringen är i dag inskränkt till registrering av järvspår som påträffas under arbete med inventering av lodjur och varg. Den viktigaste förklaringen till denna begränsade insats är att antalet vargar ökat. I takt med detta har man tvingas lägga mer tid på inventering och övrig förvaltning (t.ex. skadedokumentation) av varg i kombination med begränsade resurser och personal.

Dalarnas län

Inom renskötselområdet i nordvästra Dalarnas fjälltrakter och fjällnära skogar har det funnits en etablerad järvstam och föryngringar har dokumenterats under lång tid. I skogslandet i övriga delar av Dalarna har det däremot främst varit enstaka vandrande järvar. De senaste 5-10 åren har observationer av järvspår ökat i stora delar av länet. Uppfattningen är att ökningen främst skett i anslutning till närliggande järvetableringar i nordväst och nordöst. Dessutom är ett antal järvar etablerade i södra delarna av länet sedan 5-7 år tillbaka. Här är det främst i området kring Fredriksberg i väst till Borlänge i öst som stationära järvar spårats under ett antal år. Även om det inte kunnat bekräftas misstänker man att det skett föryngring i ett eller flera områden här. I västra delarna av länet söder om Fulufjället är det däremot glest mellan observationerna av järvspår.

Det som de flesta anger som den troligaste förklaringen till ett ökat antal järvar i länet är att vargstammen ökat och att tillgången på föda i form av älgkadaver därmed ökat. I Dalarna utanför renskötselområdet sker inventering av järv huvudsakligen genom att man dokumenterar järvspår som påträffas under arbetet med inventering av varg och lodjur. I enstaka fall samlar man in spillning för DNA-analys. Generellt kan man säga att den tid och de resurser som finns läggs på inventering av framförallt varg, men även lodjur. Utanför renskötselområdet söks det inte aktivt efter järvspår eller föryngringar.

Värmlands län

I Värmland är uppfattningen att antalet järvar ökat de senaste åren, även om det fortfarande sannolikt rör sig om ett litet antal individer. Det är framförallt i norra delen av Värmland som det regelbundet observeras järvspår och det troligen finns fast etablering av järv. I södra delarna av Värmland är det ovanligare med observationer av järvspår även om det sker då och då. Även i Värmland är inventering av varg och i lodjur prioriterat och järv inventeras endast i form av registrering av de spår som påträffas under varg och lodjursinventeringen.

9 Skillnader i metodik och insats vid inventering kan påverka bilden av järvpopulationens utbredning i skogslandet

Ett genomgående problem vid tolkning av järvpopulationens utveckling nationellt och i synnerhet i skogslandet utanför renskötselområdet är osäkerhet kring metodik och insats i inventeringen. Dessa osäkerheter handlar om förändringar i insats och metodik såväl över tid som inom och mellan områden.

9.1 Geografiska skillnader i inventeringsmetodik och insats

Det är framförallt mellan områden inom och utanför renskötselområdet som inventeringsinsats och metodik skiljer sig. Eftersom inventeringarna utgör basen för rovdjursersättning till rennäringen utförs årligen stora insatser för att dokumentera föryngringar inom renskötselområdet. Detta har man gjort sedan 1996 då det nuvarande ersättningssystemet infördes. En följd av detta är att inventeringsinsatsen är högre inom renskötselområdet än utanför, och att man därför har större erfarenhet när det gäller att dokumentera föryngringar där jämfört med områden utanför. Troligen är variationen i insats och metodik mindre inom renskötselområdet än utanför. Utanför renskötselområdet har man i de flesta områden inte prioriterat särskilda resurser eller insatser för att dokumentera föryngringar av järv. Här fokuseras det istället huvudsakligen på att notera observationer av järv, och eventuellt insamling av spillning. I många områden är inventering av varg och därefter lodjur, prioriterat inom ramen för befintliga resurser, med följden att inventering av järv sker mycket sparsamt (Intervjuer 2012). Resultatet av dessa skillnader är att andelen av förekommande järvföryngringar som faktiskt dokumenteras säkerligen är högre inom renskötselområdet jämfört med utanför renskötselområdet.

9.2 Skillnader beroende på miljöförhållanden

Ytterligare en geografisk aspekt på skillnader i inventeringseffektivitet är att inventeringsperioden är beroende av goda snöförhållanden. I fjällen och i norr är snöförhållanden för inventering generellt mer långvariga än i områden söderut och på lägre altitud. Följaktligen är tiden att inventera järv efter att lodjursinventeringen avslutats relativt kort i stora delar av skogslandet, främst utanför renskötselområdet. Snöförhållanden varierar även mellan år i samma områden. Det kan medföra att den tid som är tillgänglig för effektiv inventering varierar mellan år och därmed påverka inventeringsresultatet.

9.3 Förändring över tiden

Både inventeringsinsats och metodik förändras över tiden i många områden. I vissa områden, framförallt inom renskötselområdet, har man ökat insatsen, fått större erfarenhet och ackumulerat en större kunskap om mot vilka områden insatsen bör riktas för att finna föryngringar. Denna förändring över tiden kan sannolikt förklara en del av den ökning av antalet dokumenterade föryngringar som setts de senaste 10 åren i landet (Persson & Brøseth 2011). Detta gäller i synnerhet inventeringen av järv i skogslandet inom renskötselområdet, där inventeringsintensiteten ökat i takt med att ökad järvförekomst i skogslandet dokumenterats. I andra områden har insatsen däremot minskat över tiden. Som vi beskrivit tidigare har järvinventeringen nedprioriterats i stora delar av skogslandet utanför renskötselområdet i takt med att inventeringen av varg och/eller lodjur tagit mer resurser i anspråk. En följd av detta är att officiella inventeringssiffror kan ge en skev bild av järvstammens utveckling. En illustration av detta är Gävleborgs län. Här dokumenterade man fyra järvföryngringar mellan 1999 och 2006. Samtidigt ökade antalet observationer av järvar och spår från 2004 till 2006, då man registrerade 169 observationer (Fig. 11). Därefter har antalet observationer minskat och var 2011 nere i 25. Inventeringsdata antyder alltså ett minskat antal järvar och inga föryngringar efter 2006. Samtidigt upplever spårningspersonal att populationen troligen ökat under denna period och att det sannolikt förekommer föryngringar som inte dokumenteras (Intervjuer 2012). Dessutom har en dokumenterad ökning skett i närliggande områden i Jämtland och Västernorrland. Slutsatsen är helt enkelt att officiella inventeringsdata i vissa områden inte bara har dålig precision utan kan ge en felaktig bild av stammens utveckling.

10 Järvens ekologi i skogslandet

Vi har på senare år fått en ökad kunskap från långtidsstudier av järvars ekologi i fjäll och fjällnära skogar i renskötselområdet. Däremot har det inte samlats in mycket kunskap om järvars ekologi i skogslandet. Även om mycket av kunskapen från fjällområden förmodligen är överförbar finns det många aspekter av järvens ekologi i skogen som kan och bör belysas. I följande två avsnitt har beskriver vi vad vi vet om järvars val av lyplatser och födoval i skogslandet.

10.1 Järvars lyplatser i skogsmiljö

Länsstyrelserna i Jämtland, Västerbotten och Västernorrland har tillsammans med Järvprojektet utfört särskilda barmarkskontroller vid lyplatser under 2010 och 2011. Ett mål med dessa besök var att göra en detaljerad beskrivning av lyplatser i olika områden. Totalt har 66 lyplatser kartlagts, varav 30 var belägna i skogslandskap. Resterande lyplatser har varit belägna i fjällbjörkskog (n =19) och fjäll (n = 17). Majoriteten av lyorna i skogslandskapet har påträffats i blandskog (57 %), oftast dominerad av barrskog, eller ren granskog (30 %). De övriga påträffades i björk- (7 %), contorta- (3 %) eller tallskog (3 %).

Om vi ser på de totalt 66 besökta lyplatserna, oavsett habitat, är stenholster (64 %) och klippbranter (38 %) de vanligaste strukturerna (tabell 1). Men vilka strukturer som är vanligast skiljer sig en del mellan olika typer av habitat (skog, fjällbjörkskog och fjäll). Även då vi ser på enbart lyor i skogslandskap är stenholster den vanligaste strukturen (63 %). Men lyor i skogslandet är i större utsträckning förlagda i anslutning till trädlågor (20 %), och i mindre utsträckning i anslutning till klippbranter (23 %) jämfört med lyor i fjäll och fjällbjörkskog. Detta förklaras sannolikt av tillgång på strukturer, dvs. större trädlågor är naturligtvis vanligare i skogen medan större klippbranter är ovanligare i skogen jämfört med fjällen. I skogen har man dessutom påträffat lyor i anslutning till lite mer udda strukturer såsom stensamling efter vägbygge (n = 2), stort stenblock (n = 1) och rishög (n = 1).

När det gäller var i landskapet järvhonor placerar sina lyor i skogslandet är uppfattningen att det oftast är i svårtillgängliga, ofta branta och klippiga områden på eller i anslutning till höjder och berg (Intervjuer 2012). Det handlar ofta om platser på högre höjd med mer snö än omgivande landskap där järvarna har tillgång till branter och stenholster att förlägga lyan i. Oftast är det platser som kan uppfattas som lugna, en bit från mänsklig aktivitet, där det är svårt att till exempel köra skoter. Men det finns undantag där lyor har påträffats i flack terräng intill skogsbilväg (som dock inte används under vintern) eller i contortaplanteringar. Det är inte ovanligt att lyplatser är förlagda i närheten till förutsägbara födokällor såsom slaktgropar som används år från år.

Tabell 1. Fördelning av strukturer på alla lyplatser totalt (n = 66) och vid lyor som påträffats i skog (n = 30), fjällbjörkskog (n = 19) och på fjället (n = 17). Notera att det totala antalet dokumenterade strukturer i tabellen är högre än antalet besökta lyor i respektive habitat. Det beror på att flera strukturer ibland dokumenteras på samma lyplats.

			Habitat					
			Skogsland		**Fjällbjörk**		**Fjäll**	
Struktur	*Totalt antal*	*Andel av total*	*Antal*	*Andel*	*Antal*	*Andel*	*Antal*	*Andel*
Stenholster	42	64 %	19	63 %	9	53 %	14	82 %
Klippbrant	25	38 %	7	23 %	10	59 %	8	47 %
Trädlåga	6	9 %	6	20 %	0	-	0	-
Annat	5	8 %	4	13 %	0	-	1	6 %

10.2 Järvens födoval i skogslandet

Uppgifter från spårare (Intervjuer 2012)

Spårningspersonal har vid snöspårning eller barmarkskontroller funnit 13 olika arter som utnyttjats som föda av järv i skogslandet (om vi inte separerar sork på arter). Dessa arter är ren, älg, hare, bäver, orre, tjäder, ripa, järpe, räv, rådjur, grävling och smågnagare (lämmel och sork).

I skogslandet inom renskötselområdet är ren och älg de viktigaste födokällorna för järven. Huruvida ren eller älg är viktigast är svårt att säga och varierar mellan områden, men i områden med regelbunden tillgång på ren är renen ofta viktigast. Renar som järven utnyttjar utgörs både av renar de dödat själva och renar som dött av andra orsaker. Framförallt är det vanligt att järvar utnyttjar renar som dödats av lodjur, men även renar som dödats av varg, tåg, bil eller andra orsaker utnyttjas. Älg utgörs främst av slaktrester från älgjakten men även hela kadaver av älgar utnyttjas av järven. Många spårare vittnar om järvar regelbundet utnyttjar slaktgropar år efter år och att de förlägger lyplatser i närheten av sådana platser.

Spårare utanför renskötselområdet vittnar samstämmigt om att älg är den utan konkurrens viktigaste födokällan för järvarna i dessa områden. Genomgående påpekar man betydelsen av rester från älgjakten, då järvarna frekvent utnyttjar slaktplatser, slaktgropar och älgar som skadeskjutits under jakten. I områden med varg utgör vargdödade älgar en betydande födoresurs för järvarna.

Bortsett från ren och älg görs sparsamt med observationer av olika födoslag som järven utnyttjat. Det är svårt att se någon skillnad mellan områden innanför och utanför renskötselområdet. Spårare inom renskötselområdet har generellt dokumenterat fler arter i järvens diet. Det förklaras säkerligen av att man i renskötselområdet ägnar mer tid åt att spåra järvar och gör fler barmarkskontroller och därför påträffar mer bytesrester.

De arter som oftast påträffats vid spårning eller barmarkskontroller är framförallt skogsfågel (främst tjäder och orre, men även ripa och järpe), hare och bäver. Att järvar tagit smågnagare dokumenteras sällan på snö, men många har sett att järvar grävt i snön på ett sätt som kan tolkas som jakt efter smågnagare. Även rester av räv, grävling och rådjur har påträffats i spår efter järv eller vid lyplatser.

Eftersom järven både lever på kadaver och tar egna byten är det ofta svårt att avgöra om utnyttjade födoslag har dödats av järv eller dött av andra orsaker. I renskötselområdet har alla vi pratat med som spårat i områden med fast etablering av järv dokumenterat att järvar dödat ren. En allmän synpunkt är att järven dödar renar relativt sällan, men att järvarna vid rätt snöförhållanden i skogen kan döda ett flertal renar under kort tid. Många har uppfattningen att järvar i områden med lodjur i större utsträckning utnyttjar renar som dödats av lodjur än renar de dödat själva. Bortsett från ren är det framförallt hare, bäver och skogsfågel (främst tjäder och orre) som har dokumenterats som dödade av järv. Lyckade jakter på hare har oftast skett genom att järven har jagat haren, ofta i djup snö, till haren är utmattad och inte kan ta sig undan. Bäver har tagits genom att järven har grävt sig in i hyddor eller genom att järven har få tag i en bäver ute på backen och efter en blodig strid lyckats döda bävern. Flera spårare har noterat att järvar ofta rör sig längs vattendrag med mycket bäveraktivitet. Tjäder och orre tas oftast genom smygjakt då fåglarna ligger i snön och överraskas, ofta när det är kallt väder. Det händer även att järven tar tjäder på spelplats och en spårare noterade att han aldrig funnit så många tjäderspelplatser som när han spårat järv! Vid ett tillfälle har även kungsörn dokumenterats dödad av järv i anslutning till en vargdödad älg.

Projekt Järven i skogslandet

I Gävleborgs och Västernorrlands län bedrevs under ett antal år projektet ”Järven i skogslandet”. Det var ett projekt finansierat av Världsnaturfonden och utfördes huvudsakligen av Rune Wiklund. I ett examensarbete (Kilström 2004) sammanställdes resultat från detta projekt avseende bland annat järvarnas födoval baserat på spårningar och observationer i fält från november-april. Här rapporteras att slaktavfall från jakt (54 %) och kadaver (40 %) huvudsakligen av älg utgjorde en stor del av järvarnas diet i området. Resterande 6 % utgjordes av kadaverrester som lagts ut i närheten av lyplatser. Här noterades även att järvarna visat intresse för hare och bäver, dock utan att man kunnat dokumentera några jaktförsök. Som i de flesta studier är sannolikt små djur underrepresenterade.

Studie i Norge

I en studie baserad på spillningsanalyser i södra Norge fann man att järvars diet i skogsområden dominerades av älg (van Dijk et al. 2008). Man fann också att dieten skiljde sig mellan skogsområden med och utan varg. I områden med varg utgjordes dieten av 76 % älg och 18 % ren och i skogsområden utan varg av 42 % älg och 32 % ren. I samma studie fann man att honors diet utgjordes av mer små bytesdjur än hanars diet.

Barmarkskontroller vid lyor

Vid 30 lyplatser i skogslandet där barmarkskontroller utförts 2010-2011 var rester av ren och älg de vanligast förekommande bytesresterna (tabell 2). Även skogsfågel (tjäder och orre) dokumenterades på många lyplatser. I tillägg dokumenterades rester av hare och rådjur vid en lyplats vardera.

Tabell 2. Sammanställning av funna bytesrester vid 30 lyplatser i skogslandet i Västerbottens, Västernorrlands och Jämtlands län, 2010-2011.

	Bytesrester vid lyplats		
Art	*Antal*	*Andel*	*Antal lyplatser*
Älg	11	37%	30
Ren	11	37%	30
Skogsfågel	8	27%	30
Rådjur	1	3%	30
Hare	1	3%	30

11 Blick framåt

11.1 Kunskapsbehov

Som vi berört tidigare så finns det brister i vår kunskap om järvstammens status i delar av skogslandet. Detsamma gäller många aspekter av järvens ekologi.

Järvstammens status

När det gäller järvstammens status kan vi generellt säga att kunskapen är god inom renskötselområdet. Eftersom antalet föryngringar och förekomst är direkt relaterat till ersättningsystemet avsätts resurser till inventering av järvstammen. Mycket resurser läggs ner på att dokumentera föryngringar och i många områden samlas regelbundet spillning för DNA-analyser. I renskötselområdet är inventeringens täckningsgrad relativt god. Täckningsgraden varierar emellertid mellan områden och många spårare menar att det även inom renskötselområdet finns viktiga arealer som man inte hinner inventera och att det sannolikt missas en del föryngringar, särskilt i skogslandet (Intervjuer 2012). Detta kan leda till en underskattning av antalet föryngringar. Å andra sidan räknas föryngringar som klassificerats som sannolika in i totalberäkningar, vilket kan leda till en överskattning av stammens storlek om fler sannolika föryngringar egentligen inte var en föryngring.

Utanför renskötselområdet varierar kunskapen om järvstammens status mellan områden, men generellt är kunskapsläget avsevärt sämre än inom renskötselområdet. I många områden är inventeringsinsatsen begränsad till registrering av de järvspår som observeras i samband med inventering av varg och lodjur. Sökande efter föryngringar, uppföljning av spår och insamling av spillning är lågprioriterat. Följden av detta är att kunskapen om antalet järvar utanför renskötselområdet är betydligt sämre än inom renskötselområdet.

Eftersom förvaltningen av rovdjur i Sverige är relaterad till mål för stammarnas totala storlek bör kunskap om järvstammen även utanför renskötselområdet vara relevant för förvaltningen av järvstammen inom renskötselområdet. Det innebär att exempelvis beslut om nivåer för skyddsjakt på järv inom renskötselområdet kan påverkas av antalet järvar utanför renskötselområdet. För att få bättre kunskap om järvstammens storlek och utbredning i skogslandet utanför renskötselområdet krävs att det finns inventeringspersonal som ges tid och resurser att inventera järv. Att få ökad kunskap om föryngringar kräver resurser till spårningsarbete, samtidigt som goda snöförhållanden ofta är begränsande. Därför är tiden och möjligheterna att dokumentera föryngring relativt små. En intensivare insamling av spillning för DNA-analyser under snösäsongen kan vara ett alternativ för att få ökad kunskap om järvstammens status. DNA-inventering kan ge information om minsta antal individer och utifrån detta går det att beräkna sannolikt antal individer. Dessutom går det att i efterhand bekräfta om det skett föryngringar och få kännedom om hur populationen sprids. Detta kräver tydliga riktlinjer för hur material för DNA-analyser bör samlas in, rapporteras av insamlare och hur återkopplingen till fältpersonalen ska ske. Det är en förutsättning för att det ska upplevas som motiverat att samla in spillning. Vilket, tillsammans med resurser, i sin tur är en förutsättning för att det ska ske en bättre kartläggning av järvstammen utanför renskötselområdet.

Järvens ekologi i skogslandet

Vi har på senare år fått mycket ny kunskap om järvars ekologi genom forskningsprojektet i Jokkmokksfjällen. En stor del av denna kunskap är förmodligen överförbar till skogsområden längre söderut, men i vilken utsträckning vet vi inte. När det gäller järvar i skogslandet har vi lite kunskap om grundläggande ekologiska aspekter såsom demografi (reproduktion och dödlighet), hemområdesstorlek och habitatval. Av betydelse för inventeringar nämns ofta behovet av kunskap om födelsedatum, järvhonors val av lyplats, rörelsemönster under lyperioden, hur ofta de flyttar lyplatser och huruvida järvhonor med ungar är känsliga för störning vid lyplatser.

När det gäller födoval och predationsmönster har vi viss kunskap om järvarnas födoval under tiden det går att spåra på snö, men vi vet lite om järvarnas födoval under barmarksperioden. När det gäller snöspårning blir ofta större bytesdjur och kadaver överrepresenterade i relation till mindre bytesdjur. Särskilt intressant är kunskap om järvars predation på ren. Här finns grundläggande kunskap om exempelvis när det sker, men när det gäller hur mycket ren som järvar dödar finns lite kunskap i allmänhet och i synnerhet när det gäller järvar i skogslandet.

Eftersom järven till stor del livnär sig på kadaver är relationer till andra rovdjur av potentiellt stor betydelse. Kunskapen om järvars relation till varg inskränker sig till att järven ofta utnyttjar vargdödade älgar, att det tycks vara sällan som järven följer efter vargar och att det i andra delar av världen dokumenterats att vargar ibland dödar järvar. När det gäller relation till lodjur har vi god kunskap från områden med järv, lodjur och ren i fjäll och fjällnära skogar. Där är det väl dokumenterat att järvar till stor del utnyttjar lodjursdödade renar (Mattisson m fl. 2011). Observationer från spårare i skogslandet talar för att järvar i skogslandet utnyttjar lodjursdödade renar i liknande utsträckning (Intervjuer 2012). När det gäller relationen mellan järv och björn finns väldigt lite dokumentation. I Jokkmokksfjällen har det dokumenterats att järvar utnyttjat älgar som dödats av björn. I Nordamerika har man ett fåtal gånger dokumenterat att björnar dödat järvar i anslutning till ett kadaver.

Avslutningsvis kan vi konstatera att det finns stora kunskapsluckor när det gäller järvens status och ekologi i skogslandet. Men dessa kan förhoppningsvis fyllas i framtiden, i takt med att järven etablerar sig i skogslandet, genom förbättrad inventering och riktade fältstudier.

11.2 Framtiden för järven i det svenska skogslandet

Vår målsättning med denna rapport var att ge en så god bild som möjligt av kunskapsläget kring järvstammens status och ekologi i det svenska skogslandet. Det är uppenbart att det fortfarande finns luckor i vår kunskap om järvstammens status och ekologi i skogslandet, framförallt utanför renskötselområdet. Det är också uppenbart att antalet järvar har ökat i skogslandet såväl inom renskötselområdet som i vissa områden utanför. Därför är det naturligtvis intressant att spekulera i hur stammen kommer att utvecklas i skogslandet de närmaste åren.

De faktorer som kommer att påverka vad som sker med järvstammen i skogslandet skiljer sig delvis mellan områden inom och utanför renskötselområdet. Inom renskötselområdets skogslandskap påverkas järvstammen troligen främst av vad som sker med stammen i svenska och norska fjällområden. Även utvecklingen av lodjursstammen kan ha betydelse. Vad som sker med järvstammen i fjällen påverkar hur många unga djur som utvandrar till och etablerar sig i skogslandet. Man kan emellertid tänka sig att det finns geografiska skillnader. I vissa områden i skogslandet är järvstammen så stark att den sannolikt bidrar med utvandrare till omgivande skogsland, medan andra områden fortfarande är beroende av invandring. Antalet lodjur kan ha betydelse för järvens födotillgång, i form av renkadaver som lodjuren lämnar efter sig. Vargar å andra sidan kommer troligen att ha en fortsatt liten betydelse för järvstammen inom renskötselområdet eftersom vargförekomsten här sannolikt kommer att vara begränsad.

Utanför renskötselområdet kommer järvstammen till stor del påverkas av samma faktorer som inom renskötselområdet. Naturligtvis har även invandring från andra områden stor betydelse även här. I stora delar av skogslandet söder om renskötselområdet är det glest mellan järvarna och många observationer handlar troligen om ensamma individer som etablerat sig eller är på vandring (Intervjuer 2012). Fler järvar som invandrar innebär naturligtvis större sannolikhet att hanar och honor träffas och reproducerar sig. Älgen är det viktigaste födoslaget för järven i skogslandet utanför renskötselområdet, åtminstone höst och vinter. Tillgång på älg i form av slaktrester och kadaver kan ha stor betydelse för järvstammens fortsatta etablering och utveckling i skogslandet. Tillgången på ett varaktigt snötäcke under lyperioden kan ha betydelse för tidig ungöverlevnad hos järvar. Därmed kan man tänka sig att vintrar med mycket snö och ett varaktigt snötäcke kan ha positiv effekt på järvars reproduktion. Detta är sannolikt mer kritiskt ju längre söderut vi kommer inom järvens utbredningsområde, t.ex. i södra Dalarna.

Oavsett om vi kan förutsäga hur utvecklingen kommer att vara för järvstammen i det svenska skogslandet ser det ut som stora delar av skogslandet fått en ”ny” art som har kommit för att stanna.

12 Tack

Först vill vi tacka Världsnaturfonden som finansierat denna rapport. Vi vill också rikta ett stort tack till de naturbevakare och ideella spårare som generöst delat med sig av sina värdefulla kunskaper från sitt spårningsarbete i skogsområden från Norrbotten i norr till Värmland i söder. De vi vill tacka som bidragit med kunskap är; Per Larsson, John Halvarsson, Göran Jansson, Håkan Björling, Jan Perjons, Mats Rapp, Hans-Olov Hansson, Ole Opseth, Sture Nordlund, Hans Nordlund, Hans Nordin, Lennart Nilsson, Peter Nilsson, Urban Östman, Stefan Tågestad, Lasse Rehnfeldt, Lars Liljemark, Lars-Gunnar Wagenius, Bert-Ivan Mattsson, Bengt-Erik Göransson, Torbjörn Jonsson, Micke Sundberg, Anders Dahlén, Ulf Selin, Sonja Almroth, Mats Jonsson och Håkan Tyrén. Ett tack även till Gustaf Samelius för goda kommentarer på vår text.

13 Litteratur

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From:	A J
To:	Grizzle, Betty
Subject:	Re: Article on measuring snowpack
Date:	Tuesday, June 13, 2017 12:16:05 PM
Attachments:	2011 Perssonomslagside,1-44.pdf

Here another report with the change in wolverine distribution in Scandinavia that might be compared to the Copeland snow model but is not displayed on that model. These reports are out of date now but hopefully you can get an update from Jens or Malin.

On Tue, Jun 13, 2017 at 8:58 AM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:

> I will try again to reach out to Malin, but she did not respond to my life expectancy question that I sent last month.
>
> On Mon, Jun 12, 2017 at 9:49 AM, A J <222wsheridan@gmail.com> wrote:
>
>> I have seen an older map she prepared awhile ago in one of her reports but I haven't seen any recent version with all the more recent dens. I'm fairly certain Jens or Malin could produce this but my understanding from Jens was that you did not think you could use anything that has not been published. Perhaps a quick request to Jens would answer the question, preferably well before July when all of Sweden goes on holiday and emails go unanswered!
>>
>> Sent from my iPhone
>>
>> On Jun 12, 2017, at 8:22 AM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
>>
>> Thanks for your input on this.
>> I'm not able to share an exact date with you for the Species Status Assessment Report, but, according to our national workplan, we are required to submit a FR document (i.e., proposed rule) early next year.
>>
>> A quick question - Has Jens or Malin prepared a map of their den locations relative to the predictions from Copeland et al.'s snow model? I am not recalling one at the moment, but have been out of the office for the past 10 days (attending UC Berkeley class) so I need to go back through the papers that Malin sent.
>>
>> On Mon, Jun 12, 2017 at 9:05 AM, A J <222wsheridan@gmail.com> wrote:
>>
>>> Thanks, Betty. I read the original paper a little while ago. It's exciting stuff for those interested in snow and climate change but I think it will be quite a while before snow data from this technology will be available for wolverine researchers. We looked into LIDAR for our snowdrift work on the North Slope of Alaska but the problems with scale and cost were not encouraging. For now we will stick with aerial photography in known wolverine home ranges. We photographed about 20 areas this spring on May 28/29 where snow holes were used by wolverines and we have cameras monitoring them. Spring was at least two weeks later than last year, so lots of snowdrifts remaining. By the way, Jens went out and photographed 8 or 9 wolverine dens in southern Sweden on May 16 to document structure (no snow present). I'm hoping researchers will begin to focus on just what

happens to females and kits when snow begins to melt and into the following months when kits are still left at rendezvous sites.

I've been wondering if there is a date set for when USFWS will produce the status review and decision? Just curious.
Audrey

Sent from my iPhone

> On Jun 12, 2017, at 7:10 AM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
>
> Hi Audrey - I thought you might be interested in this article from yesterday's LA Times.
>
> --
>
> Betty J. Grizzle, D.Env.
> Fish and Wildlife Biologist
> U.S. Fish and Wildlife Service
> Carlsbad Fish and Wildlife Office
> 2177 Salk Ave, Suite 250
> Carlsbad, CA 92008
> 760-431-9440, ext. 215
> 760-431-5901 fax
> <Serna_LA Times Surveying snowpack _June 11 2017.pdf>

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Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

--

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U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office

2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

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NINA Rapport

Järv i Skandinavien

- status och utbredning 1996-2010

Jens Persson
Henrik Brøseth

Norsk institutt for naturforskning

Samarbeid og kunnskap for framtidas miljøløsninger

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Järv i Skandinavien

- status och utbredning 1996-2010

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Persson, J. & Brøseth, H. 2011. Järv i Skandinavien – status och utbredning 1996-2010. – NINA Rapport 732. 39 s.

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KONTAKTOPPLYSNINGER

NINA hovedkontor
Postboks 5685 Sluppen
7485 Trondheim
Telefon: 73 80 14 00
Telefaks: 73 80 14 01

NINA Oslo
Gaustadalléen 21
0349 Oslo
Telefon: 73 80 14 00
Telefaks: 22 60 04 24

NINA Tromsø
Framsenteret
9296 Tromsø
Telefon: 77 75 04 00
Telefaks: 77 75 04 01

NINA Lillehammer
Fakkelgården
2624 Lillehammer
Telefon: 73 80 14 00
Telefaks: 61 22 22 15

www.nina.no

Sammanfattning

Persson, J. & Brøseth, H. 2011. Järv i Skandinavien – status och utbredning 1996-2010. – NINA Rapport 732. 39 s.

Den skandinaviska järvpopulationen har sin huvudsakliga utbredning i de gemensamma skandinaviska fjällen och fjällnära skogarna. I Sverige har järvpopulationen sin huvudsakliga utbredning inom renskötselområdet från Treriksröset ner till nordvästra Dalarna. Generellt blir populationen glesare från norr till söder även om tätheten varierar lokalt. De senaste tre åren (2008-2010) var tätheten av föryngringar högst i Norrbottens västra delar ner till södra Västerbotten. Utanför renskötselområdet har järvföryngringar registrerats i skogslandet kring gränsen mellan Gävleborgs och Västernorrlands län.

I Norge hänger stora delar av järvens samman med den svenska delen av populationen, dvs. fjällkedjan mellan Norge och Sverige ner till området mellan Hedmark och Dalarna i söder, med kärnområden i Troms och Nordland fylken och glesare utbredning i Finnmark. Dessutom finns järv i centrala och östra delar av södra Norge. Utbredningen av järv i dessa delar hänger delvis ihop med järvstammen i Jämtland och Dalarna. Även om utbredningen av föryngringar tyder på en förhållandevis sammanhängande population visar genetiska analyser att den skandinaviska järvpopulationen kan delas upp i tre delar: 1) En huvudpopulation från sydöstra Norge öster om riksväg 3 i Østerdalen upp till Trondheim, Nord-Trøndelag och Nordland fylken, samt hela den svenska populationen från Dalarna i söder upp till norra Norrbotten, 2) Sydvästra Norge väster om Østerdalen, samt 3) Nord-Norge (Troms och Finnmark).

Totalt i Skandinavien registrerades 2008-2010 i genomsnitt 161 föryngringar per år. Dessa fördelade sig på i genomsnitt 104 föryngringar årligen i Sverige och 57 föryngringar i Norge. Detta motsvarar 879-1193 (90 % CI) individer totalt i Skandinavien, och 552-790 (90 % CI) i Sverige samt 308-426 (90 % CI) i Norge. Från 1996 till 2010 har antalet järvföryngringar som registrerats i Sverige ökat med i genomsnitt 3,8 % per år. I Norge har antalet registrerade föryngringar ökat med i genomsnitt 5,3 % per år under samma period. Den uppskattade populationsstorleken i Skandinavien har ökat med i genomsnitt 4,3 % årligen, från omkring 600 individer 1998 till omkring 1000 individer 2010.

Jens Persson, Grimsö forskningsstation, Inst. för ekologi, SLU, 730 91 Riddarhyttan. jens.persson@slu.se. Henrik Brøseth, Rovdata, Norsk institutt for naturforskning, NO-7485 Trondheim. henrik.broseth@nina.no

Abstract

Persson, J. & Brøseth, H. 2011. The Scandinavian wolverine population – status and distribution 1996-2010. – NINA Report 732. 39 pp.

The Scandinavian wolverine population is mainly distributed in the mountain area between Sweden and Norway, and in the nearby forest areas. In Sweden the wolverine population is distributed within the reindeer herding area, from Treriksröset to the north-western parts of Dalarna. Generally speaking the population get thinner the further south you go, although there are local variations in density. The last three years (2008-2010) the density of annual reproductions was highest in the western part of Norrbotten to the southern parts of Västerbotten. Outside the reindeer herding area reproductions have also been registered in the forest areas around the border between the Swedish counties of Gävleborg and Västernorrland.

A large part of the Norwegian wolverine population is connected with the Swedish population, in the mountain areas between Norway and Sweden. This part of the distribution area stretches down to Hedmark in southern Norway and Dalarna in southern Sweden, with the highest population densities in the counties of Troms and Nordland, and lower densities in Finnmark County. In addition, there are wolverines distributed in the central and eastern parts of southern Norway. This part of the population is connected to the Swedish population in Jämtland and Dalarna. Even if the distribution of reproductions shows a relatively continuous distribution, genetic analysis show that the Scandinavian wolverine population can be divided into three genetic subpopulations: 1) A main population in south-eastern Norway, east of Highway 3 through Østerdalen up to Trondheim, Nord-Trøndelag and Nordland, including the whole Swedish population from Dalarna in the south to the northern parts of Norrbotten, 2) South-western Norway, west of Østerdalen, and 3) Northern Norway (Troms and Finnmark).

The average number of annual reproductions from 2008-2010 was 161 in total for Scandinavia. The average number of reproductions in Sweden was 104, while in Norway it was 57. This corresponds to a total population size of 879-1193 (90% CI) adult individuals in Scandinavia, with 552-790 (90 % CI) in Sweden and 308-426 (90 % CI) in Norway. From 1996 to 2010 the number of registered reproductions has increased with 3.8 % per year. In Norway the annual number of registered reproductions has increased with 5.3 % on an average in the same period. The estimated population size in Scandinavia has had an annual average increase of 4.5 %, from around 600 individuals in 1998 to around 1000 individuals in 2010.

Jens Persson, Grimsö Wildlife Research Station, Department of Conservation Biology, Swedish University of Agricultural Sciences, SE-730 91 Riddarhyttan, Sweden. jens.persson@slu.se. Henrik Brøseth, Rovdata, Norwegian Institute for Nature Research, NO-7485 Trondheim, Norway. henrik.broseth@nina.no

Innehåll

Förord

Denna rapport är den första där det sker en gemensam rapportering av järvpopulationens status och utbredning på den skandinaviska halvön. Detta steg är logiskt eftersom det handlar om en gemensam population som breder ut sig över nationsgränserna och påverkas av vad som sker på båda sidor gränsen.

Under arbetet med denna rapport har vi fått värdefull hjälp med att sammanställa inventeringsdata på järv i Norge och Sverige från perioden 1996 till 2010. Vi vill särskilt tacka personal hos Fylkesmenn, Statens Naturoppsyn och Länsstyrelserna, samt Linn Svensson på Viltskadecenter.

Vi vill uppmärksamma att kartpunkterna som förekommer i denna rapport är förskjutna så att det inte är möjligt att ta ut exakta koordinater på järvlyor.

Grimsö och Trondheim, 31.05.2011.

Jens Persson   Henrik Brøseth

Järvens livsmiljö på skandinaviska halvön

Enligt en tidigare analys utgörs omkring hälften av den skandinaviska halvön av lämpligt habitat för järv, huvudsakligen norr om Dalarna och Gävleborg (Lande m fl. 2003). Förmodligen är detta en konservativ bedömning eftersom analysen till stor del bygger på data från järvens utbredning fram till 2001 i fjällområden och troligen underskattar habitatkvalitet i delar av norra Svealands och Norrlands skogslandskap i Sverige, samt i lägre liggande skogslandskap i delar av Trøndelag, Møre och Romsdal, Hedmark och Oppland fylken i Norge. Sedan analysen gjordes har också delar av järvpopulationen etablerat sig utanför de områden som angavs som mest lämpliga i analysen. Eftersom det finns mycket outnyttjat järvhabitat kan vi utgå ifrån att järvpopulationen befinner sig långt under den biologiska bärförmågan och att det finns utrymme för avsevärt fler järvar än idag, ur ett biologiskt perspektiv.

I ett strikt kvantitativt avseende sker sannolikt en minskning av järvens habitat i takt med att det byggs vägar, vindkraftverk, skidanläggningar etc. Men det är inte möjligt inom ramen för denna rapport analysera detta och det är sannolikt av marginell betydelse för järvpopulationen ur ett nationellt perspektiv och inom ett överskådligt tidsperspektiv. Omfattningen av tillgängligt järvhabitat bör anses vara relativt stabil och i tillräcklig mängd och av tillräckligt hög kvalitet för att härbärgera populationen på lång sikt. Möjligen kan den ökade vargstammen i Mellansverige och sydöstra Norge medföra att livsmiljöns potential att härbärgera järvar har ökat, dvs. tillgången på kadaver som järvar kan tillgodogöra sig ökar med ett ökat antal vargar (van Dijk m fl. 2008). I ett längre tidsperspektiv kan dock klimatförändringar (global uppvärmning) resultera i en minskad livsmiljö för järven (t.ex. Schwartz m fl. 2009; Copeland m fl. 2010; Peacock 2011).

Inventering av järv i Skandinavien

I både Sverige och Norge inventeras järvstammen huvudsakligen genom registrering av föryngringar. Föryngringar fastställs genom lokalisering av järvlyor och/eller observationer av honor med ungar eller deras spår. I Sverige har länsstyrelserna ansvar för det praktiska arbetet med och länsvis sammanställning av registrering av föryngringar. Viltskadecenter ansvarar för sammanställning på nationell nivå. I Sverige finns ingen nationell kvalitetskontroll av inventeringen. I Norge utförs inventeringarna av Statens Naturoppsyn (SNO) och av SNO utsedda rovviltkontakter, medan Rovdata vid NINA (Norsk institutt for naturforskning) har ett övergripande ansvar för sammanställning och kvalitetskontroll (Brøseth m fl. 2010b). Registrerade lyor klassificeras som ”säker föryngring” (dokumentation av ungar eller spår av ungar) eller ”sannolik föryngring” (dokumentation av lyplats men inte ungar). Inventeringen genomförs i huvudsak på snöföre under perioden mars-maj. Därutöver utförs barmarkskontroller på lokaler där eventuella föryngringar har en osäker status efter snöperiodens registreringsarbete. Vid barmarkskontroller registrerar man förekomst av kriterier (spårtecken) som tyder på att reproduktion har skett på platsen innevarande år. Uppfylls dessa kriterier klassas föryngringen som sannolik. Vid inventeringen av järvföryngringar använder man sig huvudsakligen av samma kriterier vid bedömning av sannolika föryngringar i Sverige och Norge, även om de skiljer sig i vissa avseenden (se Brøseth och Andersen 2009). Demografiska data (ålder för första reproduktion, andelen honor som reproducerar sig varje år, könskvot etc.) från forskningsprojekten används för att beräkna den totala järvpopulationen på basis av antalet föryngringar (Landa m fl. 1998).

I Sverige dokumenteras även observationer av järvar och spår av järvar. I renskötselområdet har denna dokumentation betydelse för ersättningssystemet då samebyar kan ersättas för regelbunden respektive tillfällig förekomst av järv om ingen föryngring dokumenteras i samebyn.

DNA-analyser av järvspillning kan användas för att inventera antal individer i en population eller för att vid vissa tillfällen t.ex. särskilja familjegrupper (Flagstad m fl. 2010). Provmaterial (främst spillning), samlas in av fältpersonal i samband med registreringar av föryngringar. Från spillning extraheras kärn-DNA och det fastställs genotyp för att identifiera individer. Alla prov som ger järvspecifikt kärn-DNA blir också könsbestämda med hjälp av två könsmarkörer. Resultaten används för att analysera populationsstorlek och -differentiering, könsfördelning, spridning och släktskap. DNA-metoden används omfattande på nationell nivå i Norge för att beräkna antalet individer i populationen (Brøseth m fl. 2010a; Flagstad m fl. 2008). I Sverige används metoden främst som ett komplement för att öka säkerheten i särskiljning av närliggande järvlyor.

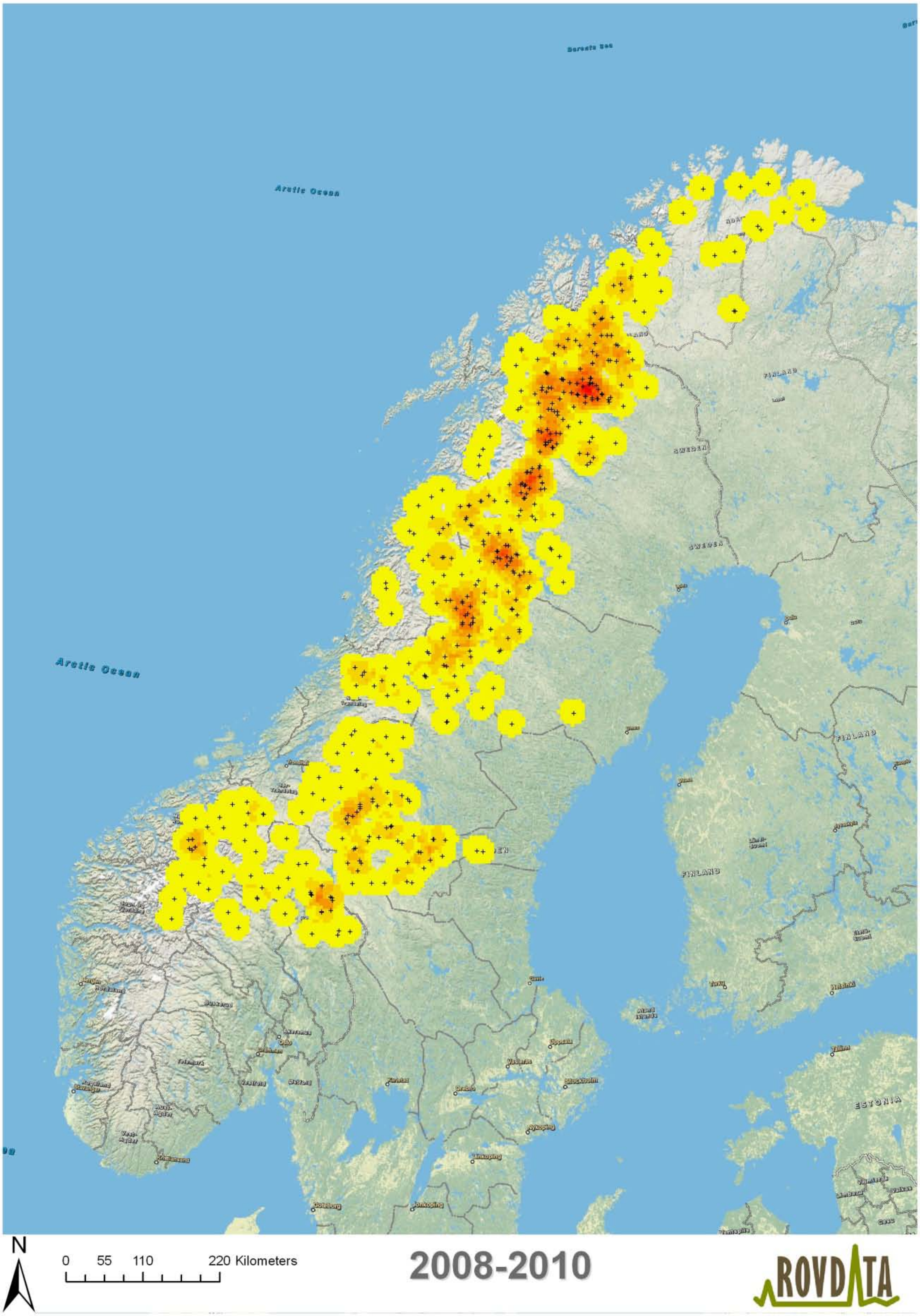
Järvens utbredning i Skandinavien

Sverige

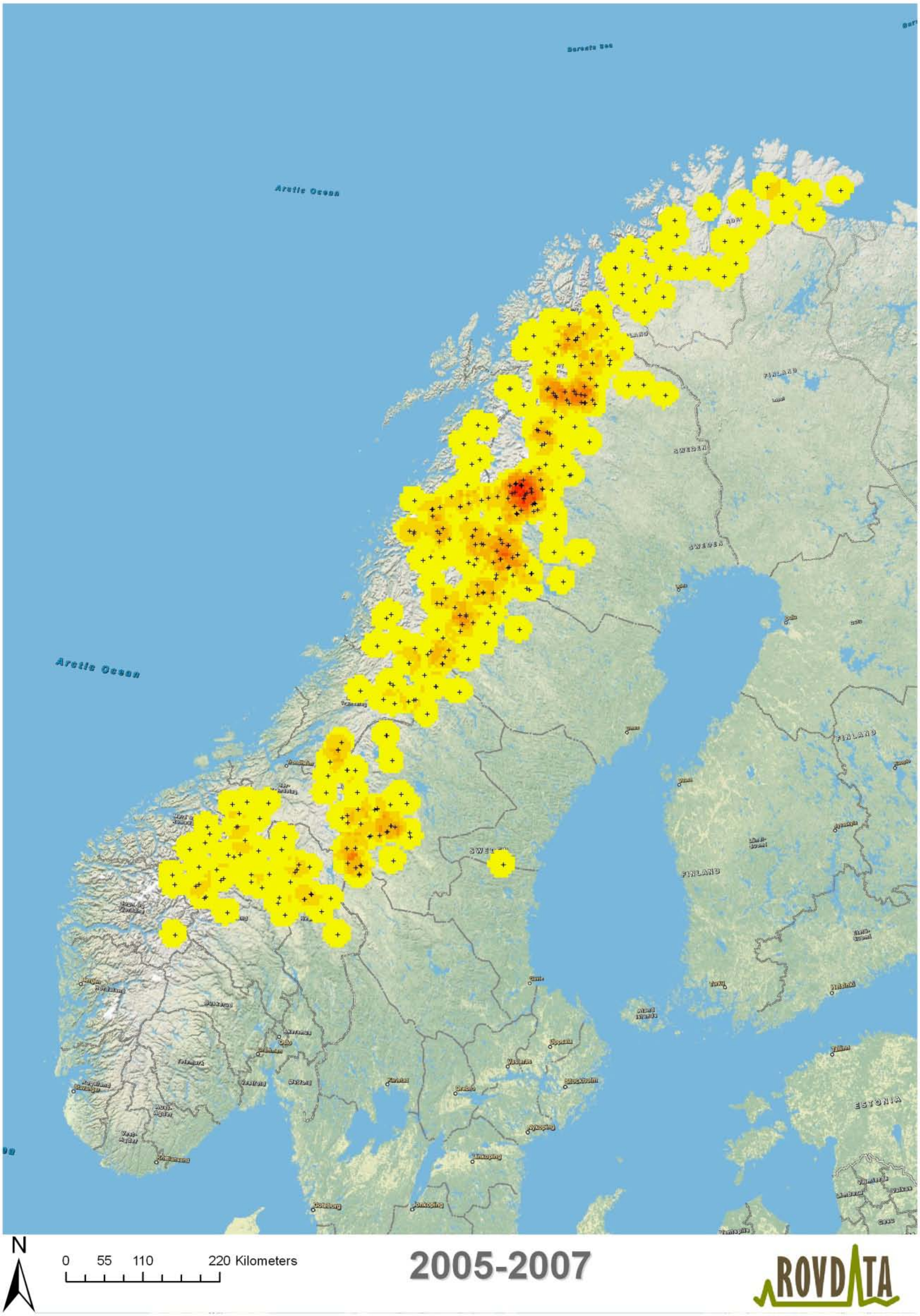
Den svenska delen av järvpopulationen har sin utbredning i huvudsak inom renskötselområdet längs fjällkedjan och i fjällnära skogar från Treriksröset ner till nordvästra Dalarna (**figur 1a**). Generellt blir populationen glesare från norr till söder även om tätheten varierar lokalt inom de olika länen. Om vi ser på registrerade föryngringar de senaste tre åren (2008-2010) finner vi kärnområden med högst täthet av föryngringar i Norrbottens västra delar ner till södra Västerbotten. Den relativt sett lägre tätheten av föryngringar i centrala och norra Jämtland, samt centrala delar av Nord-Trøndelag i Norge, skapar ett visst glapp mellan en nordlig och en sydlig del av järvens utbredning i Sverige. Lyorna i Dalarna har alla varit lokaliserade i fjällområden i nordvästra hörnet av länet. Utanför renskötselområdet har det registrerats järvföryngringar i skogslandet kring gränsen mellan Gävleborgs och Västernorrlands län. I detta område har man registrerat 8 föryngringar sedan 1999. Genetiska data tyder på att föryngringar förekommit i dessa områden som inte dokumenterats i fält (Flagstad m fl. 2007). Dessutom tyder antal observationer av järvar på att järvstammen expanderar i skogslandet åt öster och söder både inom och utanför renskötselområdet.

Norge

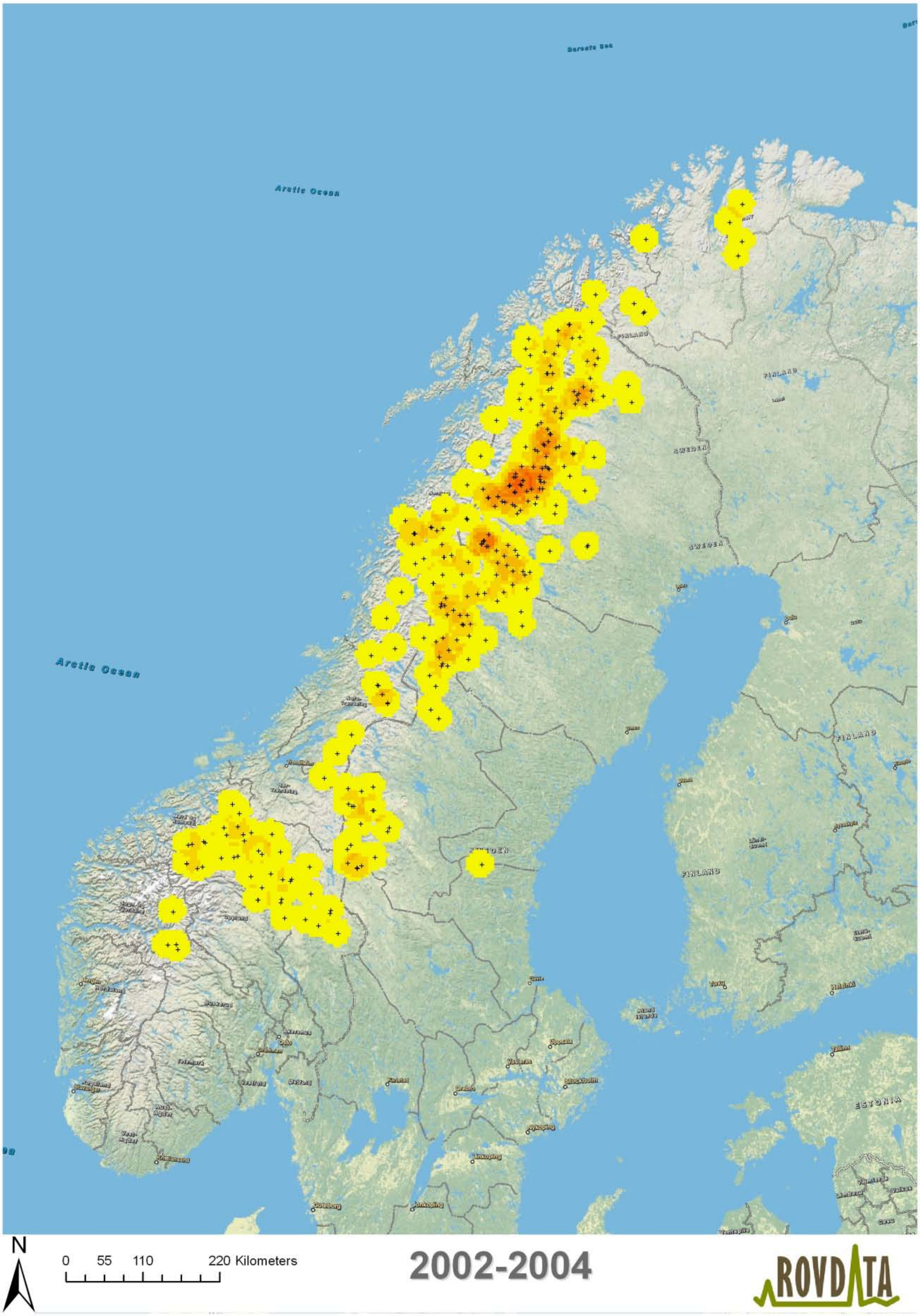
Stora delar av järvens utbredning i Norge hänger samman med den svenska populationen, dvs. fjällkedjan från Finnmark i norr till Hedmark i söder, med kärnområden i Troms och Nordland fylken och glesare utbredning i Finnmark (**figur 1a; 2**). Dessutom finns järv i de centrala och östra delarna av södra Norge. Utbredningen av järv i dessa delar hänger delvis ihop med järvstammen i Jämtland och Dalarnas län. Även om en karta med utbredning av föryngringar tyder på en förhållandevis sammanhängande population visar genetiska analyser att den norska delen av järvpopulationen kan delas upp i tre delar (se avsnittet om Uppdelning av delpopulationer).



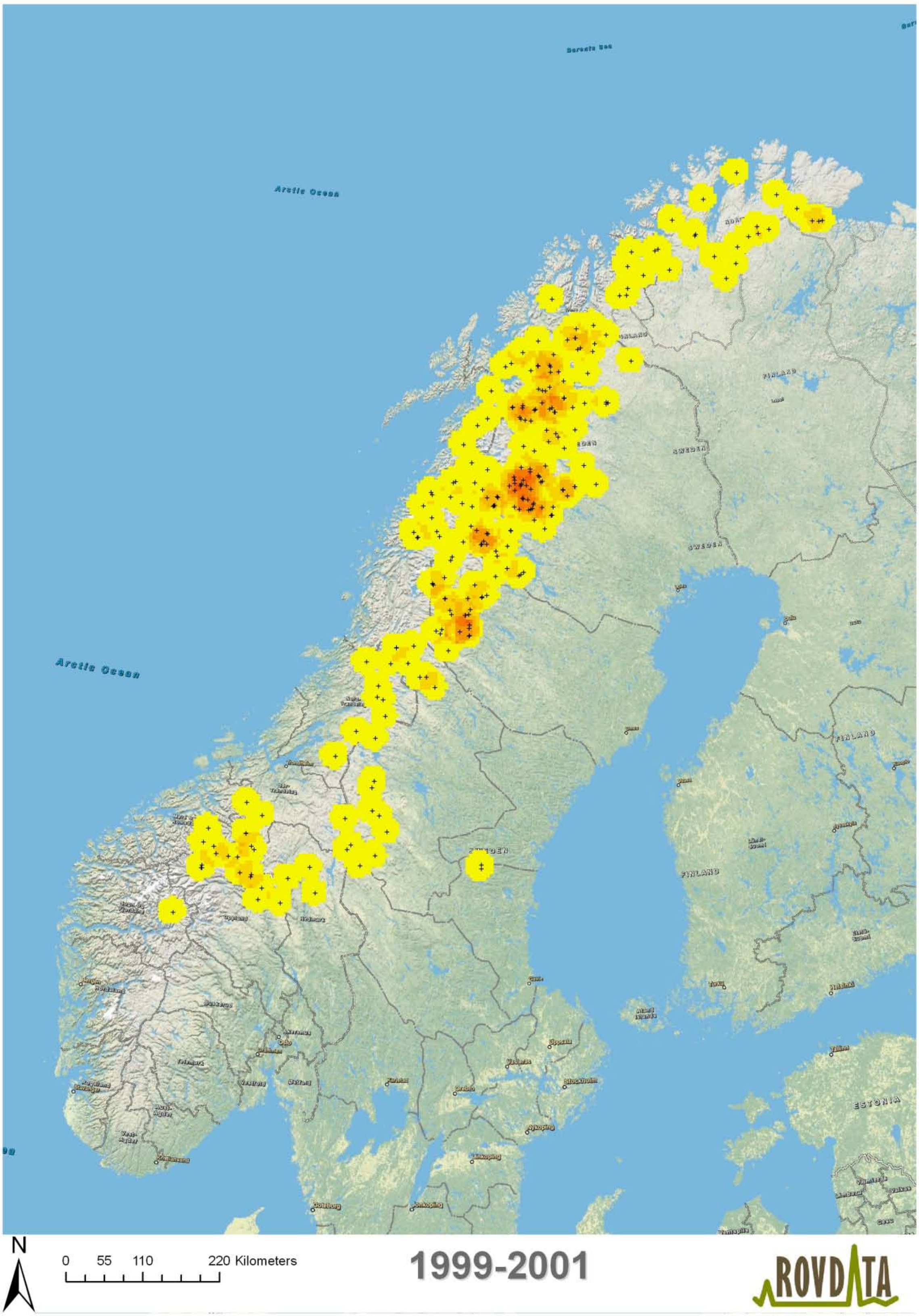
Figur 1a*. Utbredning av föryngringar de senaste tre åren (2008-2010) i Sverige och Norge. Färgmarkering illustrerar en buffertzon på 20 km runt registrerade föryngringar (svarta kors) och röd-gul indikerar hög respektive låg täthet av föryngringar under dessa år. Källa: Rovdjursforum och Rovbase.*



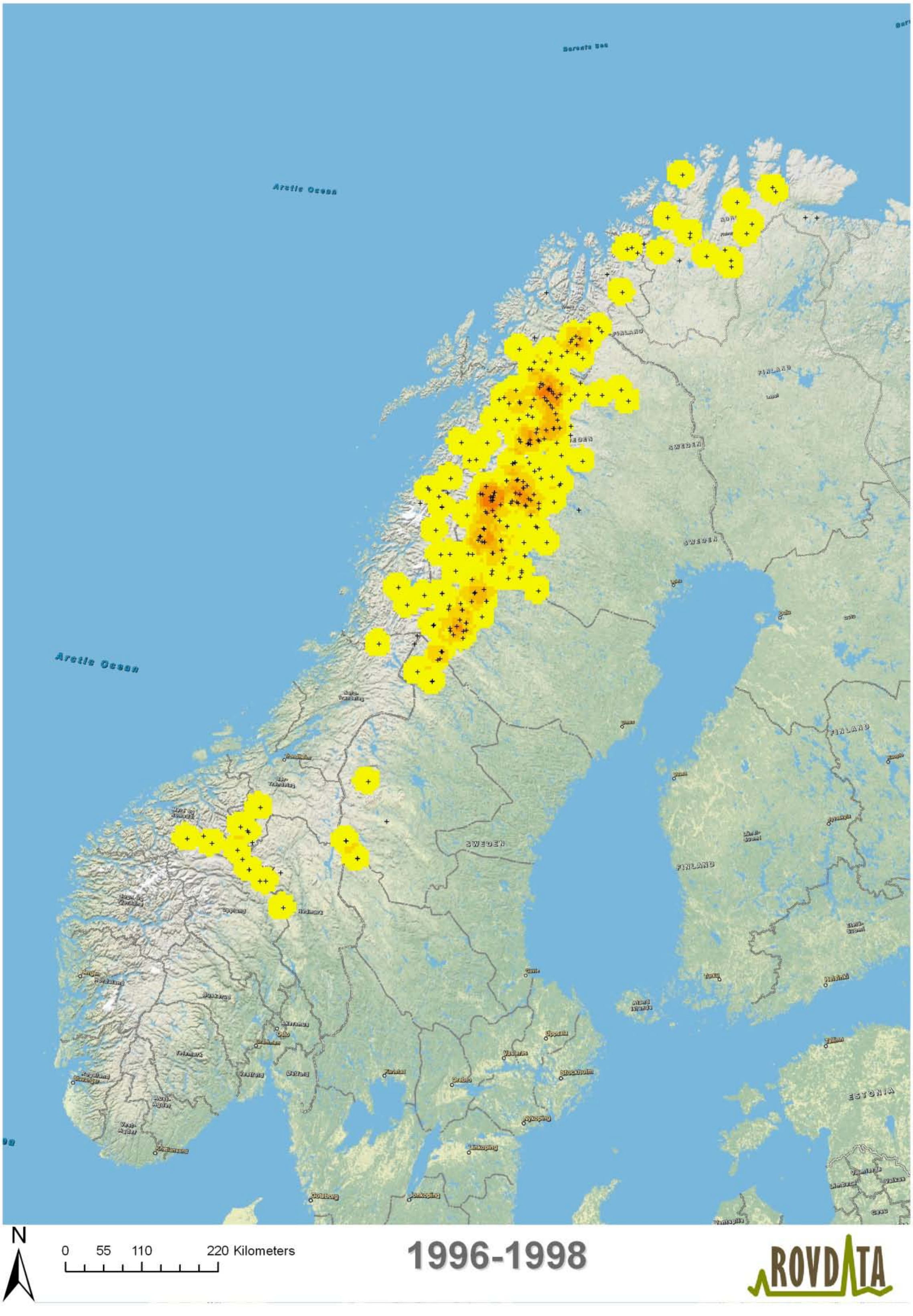
***Figur 1b**. Utbredning av föryngringar 2005-2007 i Sverige och Norge. Färgmarkering illustrerar en buffertzon på 20 km runt registrerade föryngringar (svarta kors) och röd-gul indikerar hög respektive låg täthet av föryngringar under dessa år. Källa: Rovdjursforum och Rovbase.*



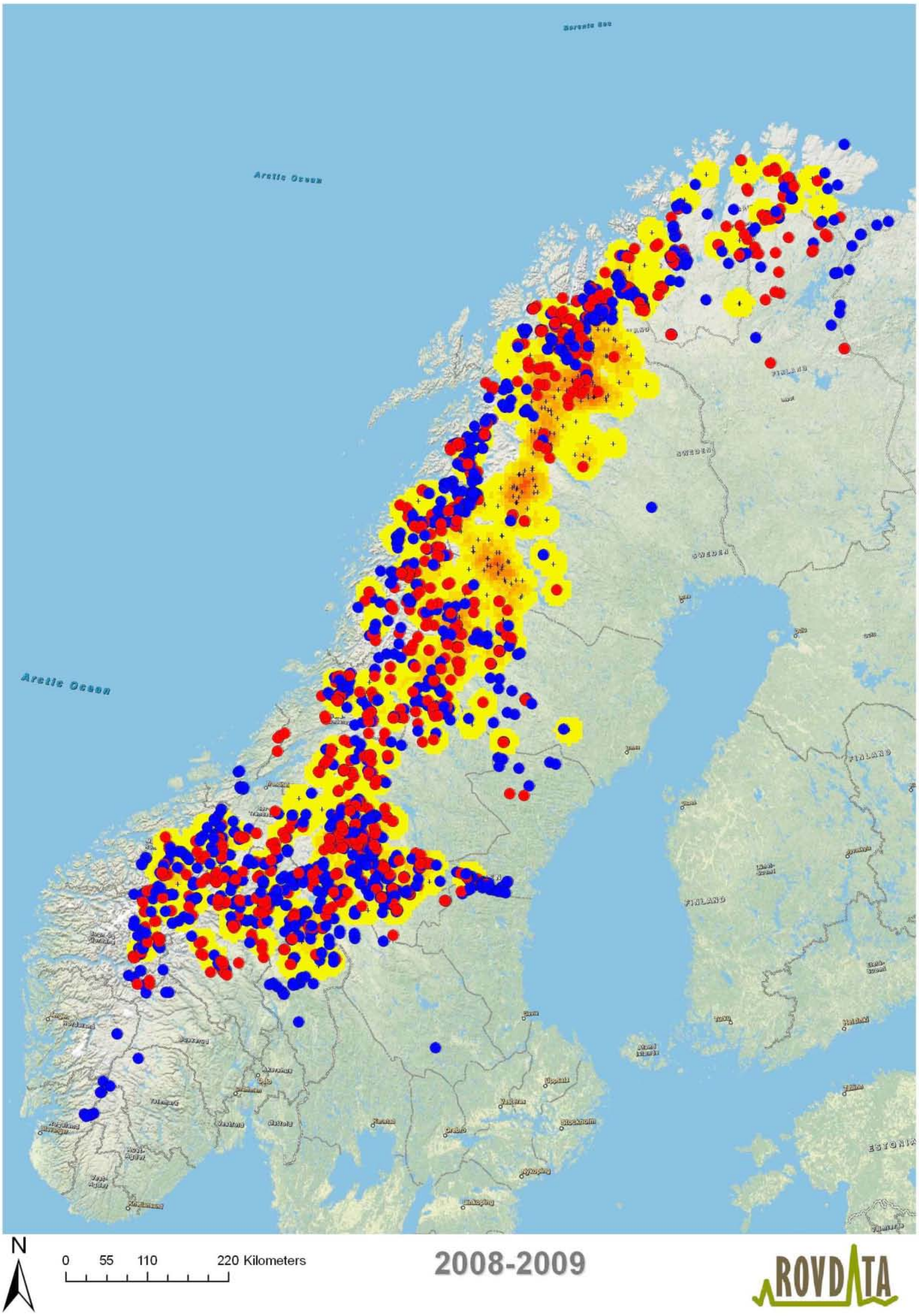
Figur 1c. *Utbredning av föryngringar 2002-2004 i Sverige och Norge. Färgmarkering illustrerar en buffertzon på 20 km runt registrerade föryngringar (svarta kors) och röd-gul indikerar hög respektive låg täthet av föryngringar under dessa år. Källa: Rovdjursforum och Rovbase.*



***Figur 1d**. Utbredning av föryngringar 1999-2001 i Sverige och Norge. Färgmarkering illustrerar en buffertzon på 20 km runt registrerade föryngringar (svarta kors) och röd-gul indikerar hög respektive låg täthet av föryngringar under dessa år. Källa: Rovdjursforum och Rovbase.*



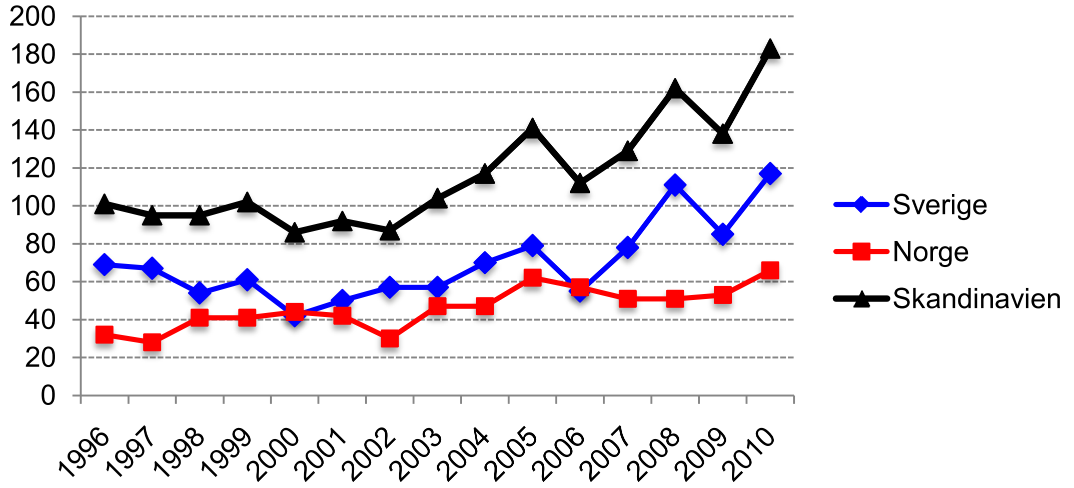
Figur 1e. *Utbredning av föryngringar 1996-1998 i Sverige och Norge. Färgmarkering illustrerar en buffertzon på 20 km runt registrerade föryngringar (svarta kors) och röd-gul indikerar hög respektive låg täthet av föryngringar under dessa år. Källa: Rovdjursforum och Rovbase.*



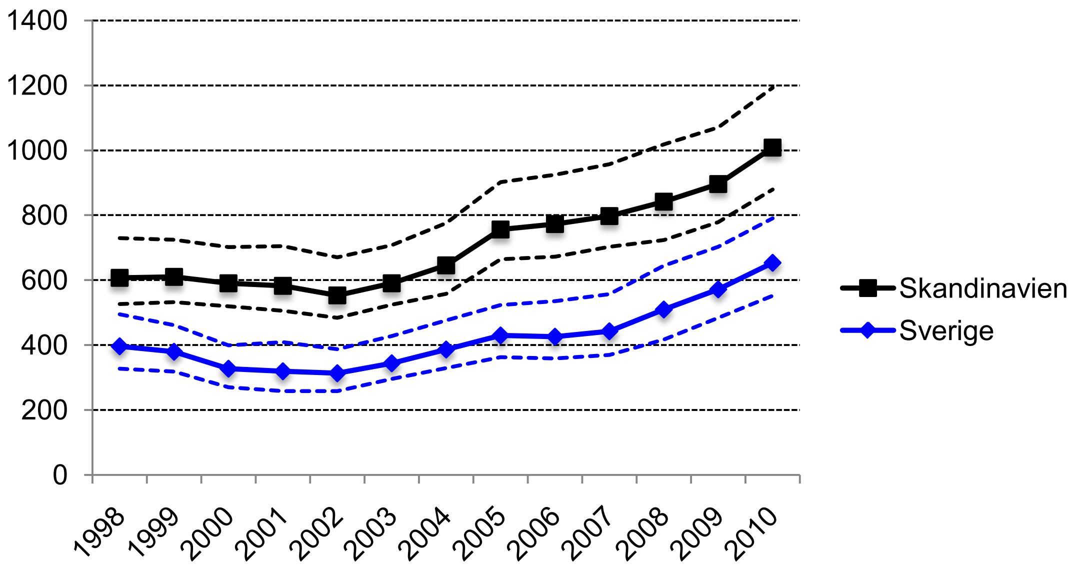
***Figur 2**. Individbestämda DNA-prover från järvar i Skandinavien 2008-2009 (honor = röda prickar; hanar = blå prickar). Färgmarkering (gul-röd) illustrerar en buffertzon på 20 km runt registrerade föryngringar 2008-2010 (reproduktionsområdet). Observera att insamlingen av DNA-prover varierat mellan olika regioner och därför inte ger en representativ bild av järvförekomst. Insamlingen har varit mest intensiv i Norge och Jämtlands län. Lägre i Norrbotten och Finland. Från rysk sida finns inga prover.*

Järvpopulationens storlek i Skandinavien

Totalt i Skandinavien registrerades 2008-2010 i genomsnitt 161 föryngringar per år (**figur 3**). Dessa fördelade sig på i genomsnitt 104 föryngringar årligen i Sverige och 57 föryngringar i Norge. Detta motsvarar 1009 (879-1193; 90 % CI) individer totalt i Skandinavien, varav 654 (552-790; 90 % CI) i Sverige samt 355 (308-426; 90 % CI) i Norge[1]. Den beräknade populationsstorleken i Skandinavien har ökat med i genomsnitt 4,3 % per år från 1998 till 2010 (**figur 4-5**; men se ”Kommentarer kring populationsutvecklingen”).

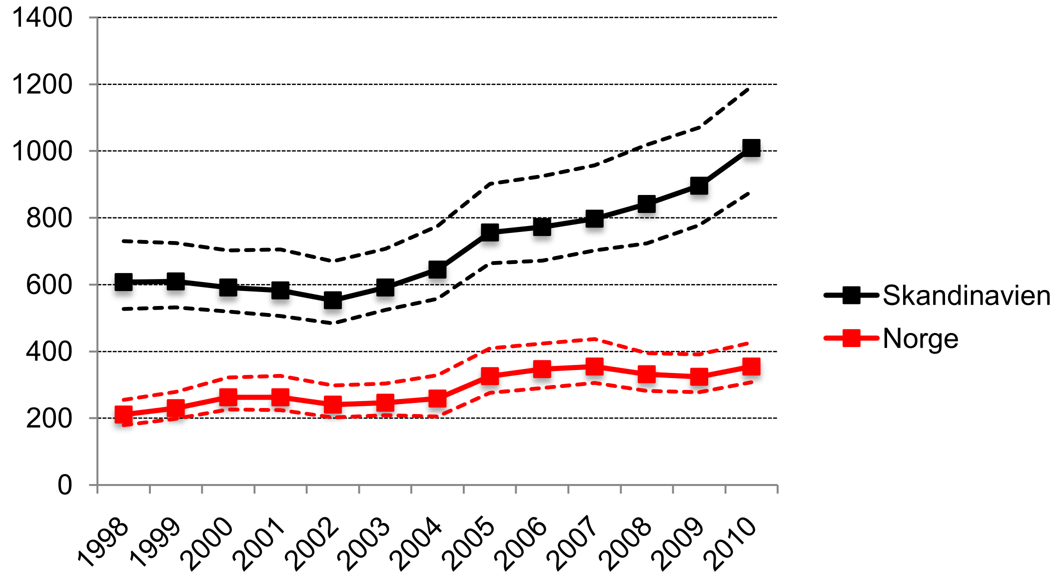


***Figur 3**. Antal registrerade järvföryngringar (säkra och sannolika) i Skandinavien, Sverige och Norge från 1996-2010. Figuren baseras på data i **tabell 1**.*



***Figur 4**. Antal järvar i Skandinavien (svart) och Sverige (blå), baserat på omräkning av antal föryngringar till antal individer. Antal individer ett specifikt år är omräknat från genomsnitt av antal föryngringar de senaste tre åren. Streckade linjer anger 90 % konfidensintervall för antalet individer i respektive område.*

[1] Omräkning av antal föryngringar till antal individer baseras på genomsnitt antal föryngringar de senaste tre åren. Data som använts vid dessa beräkningar är: andel av vuxna honor som reproducerar sig = 62,1%; könsfördelning = 56,8% honor; andel honor som reproducerar sig första gången vid 2, 3, 4 och 5 års ålder är 5, 60, 29 respektive 6 %. Beräkningarna baseras på data från märkta järvar i Sarek, och DNA-data från norska övervakningssystemet (Brøseth m fl. 2010a).

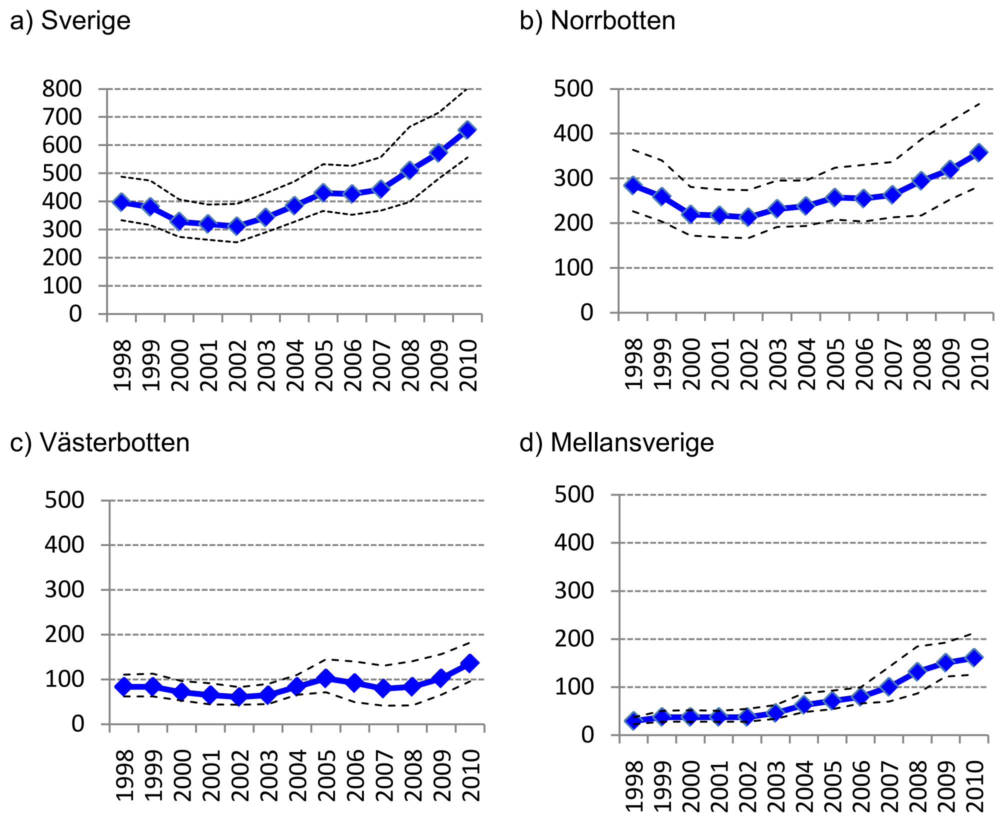


Figur 5*. Antal järvar i Skandinavien (svart) och Norge (röd). Antal individer ett specifikt år är omräknat från genomsnitt av antal föryngringar de senaste tre åren. Streckade linjer anger 90 % konfidensintervall för antalet individer i respektive område.*

I Sverige har trenden i antal föryngringar varit starkt påverkad av utvecklingen i Norrbotten (**figur 6**). Sedan 1996 har årligen 54-76 % av föryngringarna registrerats i Norrbotten (medel 62 %). Emellertid har Norrbottens andel av det totala antalet föryngringar i landet minskat under senare år. Från att under inventeringarnas första tre år (1996-1998) ha svarat för 71 % av landets föryngringar var motsvarande siffra för de senaste tre åren (2008-2010) 55 %, trots att antalet föryngringar har ökat även i Norrbotten under senare år. Detta beror främst på att antalet föryngringar ökat avsevärt i Jämtland, vars andel av landets föryngringar ökat från 6 % (1996-1998) till 23 % (2008-2010).

Sedan inventeringarnas start 1996 till 2010 har antalet järvföryngringar som registrerats i Sverige ökat med i genomsnitt 3,8 % per år. Ökningen är tydligast de senaste 10 åren (2000-2010; **figur 3**). Ser vi på länsnivå så är det främst i Norrbotten och Jämtland antalet föryngringar har ökat. Om vi ser på den svenska järvpopulationen utifrån förvaltningsområden så innehar det nordliga förvaltningsområdet (Norrbotten, Västerbotten, Jämtland och Västernorrland) 99 % och det mellersta förvaltningsområdet 1 % av föryngringarna.

Även i Norge har det 1996-2010 varit en ökning i antal föryngringar med i genomsnitt 5,3 % per år. Under perioden 1996-1998 registrerades i genomsnitt 34 årliga föryngringar i Norge, medan motsvarande antal under perioden 2008-2010 var 57, dvs. en ökning med 68 %. I Norge är det speciellt i centrala och sydliga delar av utbredningsområdet som ökningen varit störst (Nord-Trøndelag och Sør-Norge; **figur 1 a-e, figur 7 e-f**). I dessa områden har antal föryngringar ökat från ett genomsnitt på 7 föryngringar 1996-1998 till 27 föryngringar 2008-2010 (**tabell 1**).

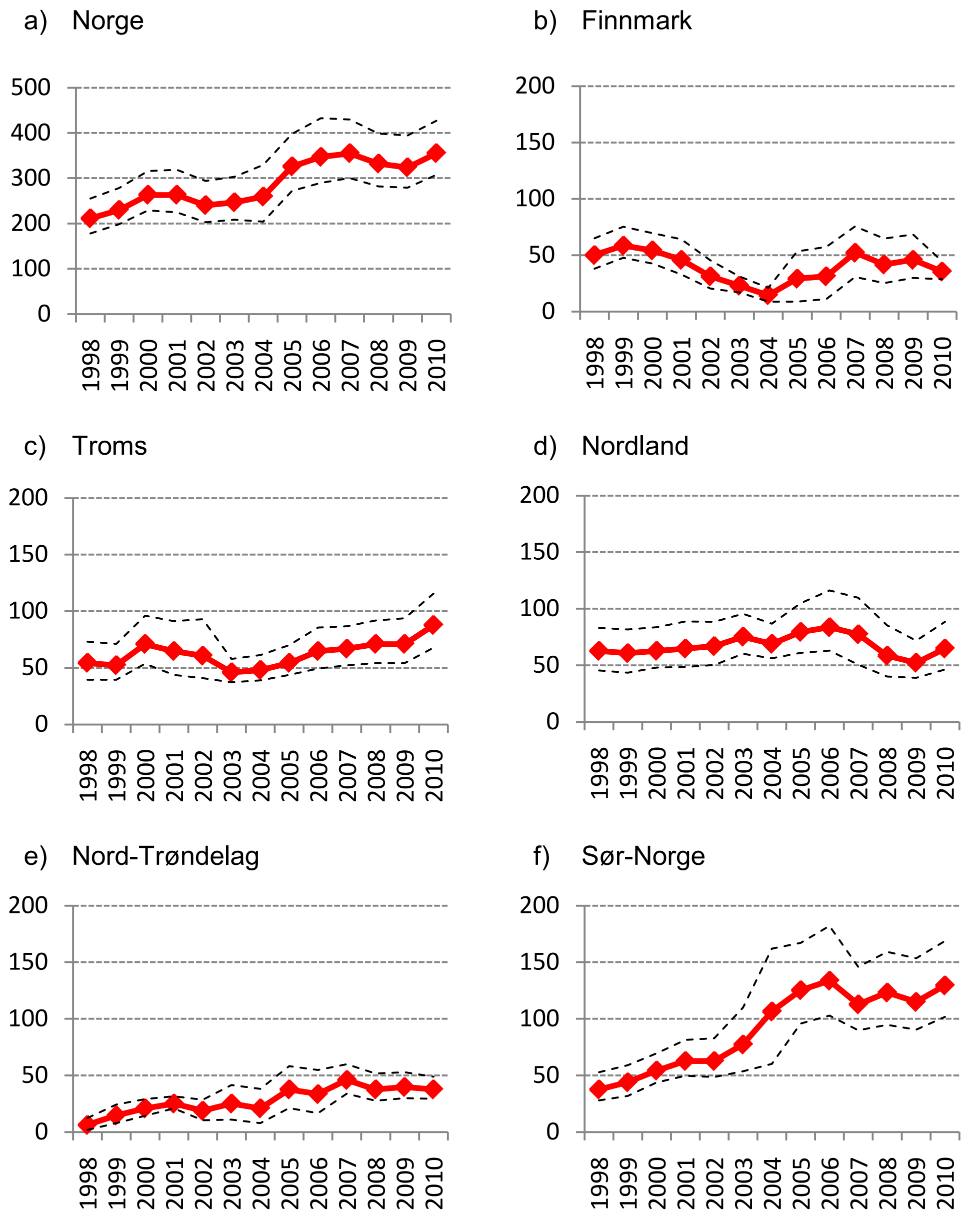


***Figur 6**. Antal järvar (1998-2010) beräknat för a) Sverige totalt, och separat för b) Norrbotten, c) Västerbotten, och d) Mellansverige (Jämtlands, Västernorrlands, Gävleborgs och Dalarnas län). Streckade linjer anger 90 % konfidensintervall för antalet individer i respektive område.*

***Tabell 1**. Antal registrerade järvföryngringar i Sverige och Norge 1996-2010 uppdelade på län respektive fylke[2].*

	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
Finnmark	6	9	9	10	7	5	3	3	1	10	4	11	5	6	6
Troms	10	6	10	9	15	7	7	8	8	10	13	9	12	13	17
Nordland	11	7	12	10	8	13	11	12	10	16	14	7	7	11	13
Nord-Trøndelag	0	1	2	4	4	4	1	7	2	9	5	8	5	6	7
Sør-Trøndelag	1	2	2	1	2	3	2	4	3	3	3	2	3	4	4
Møre og Romsdal	1	0	1	0	2	3	1	3	4	3	2	3	6	3	4
Oppland	3	3	4	6	5	4	4	3	6	7	6	6	5	3	5
Hedmark	0	0	1	1	1	1	1	6	10	4	10	4	8	5	10
Sogn og Fjordane	0	0	0	0	0	1	0	1	3	0	0	1	0	2	0
Norge	**32**	**28**	**41**	**41**	**44**	**41**	**30**	**47**	**47**	**62**	**57**	**51**	**51**	**53**	**66**
Norrbotten	50	47	39	38	28	38	36	37	41	45	36	45	60	48	63
Västerbotten	15	15	10	15	9	7	13	11	16	22	6	10	24	15	26
Jämtland	3	4	4	7	4	4	6	8	11	9	12	21	25	21	23
Västernorrland	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
Gävleborg	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
Dalarna	1	1	1	0	0	1	1	1	2	3	0	2	1	0	3
Sverige	**69**	**67**	**54**	**61**	**42**	**50**	**57**	**57**	**70**	**79**	**55**	**78**	**111**	**85**	**117**

[2] – Antal föryngringar i olika län/fylken i olika år kan avvika från officiella siffror som angetts i tidigare rapporter. Dessa skillnader beror på att vi vid en grundlig genomgång av data påträffat dubbelräkningar av föryngringar. Speciellt gäller detta föryngringar som registrerats både i Sverige och Norge.

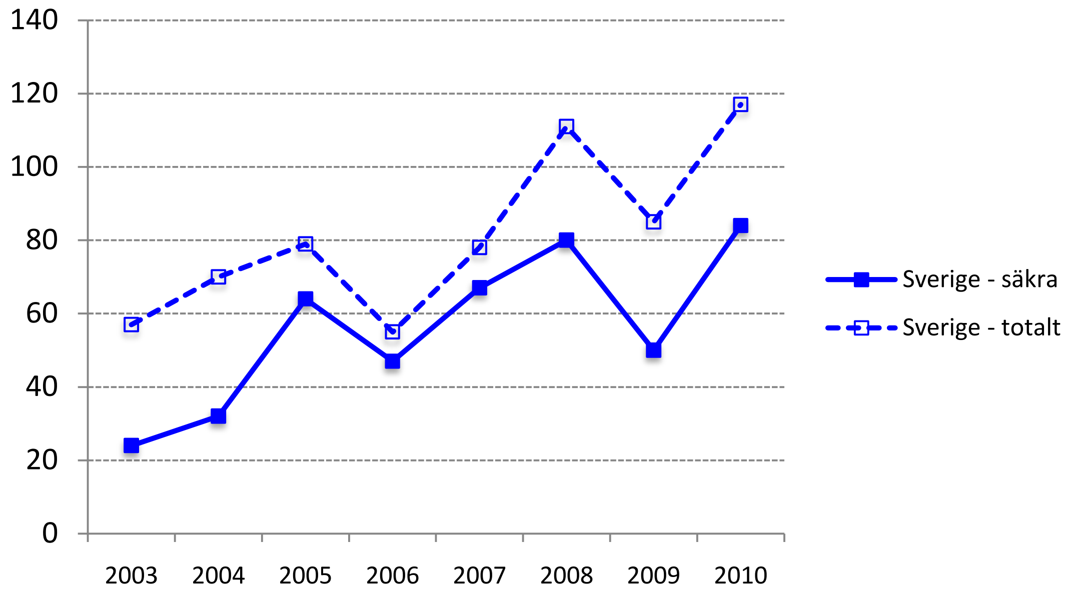


***Figur 7**. Antal järvar beräknat för a) Norge totalt, och separat för b) Finnmark, c) Troms, d) Nordland, e) Nord-Trøndelag, och f) Sør-Norge (1998-2010). Streckade linjer anger 90 % konfidensintervall för antalet individer i respektive område.*

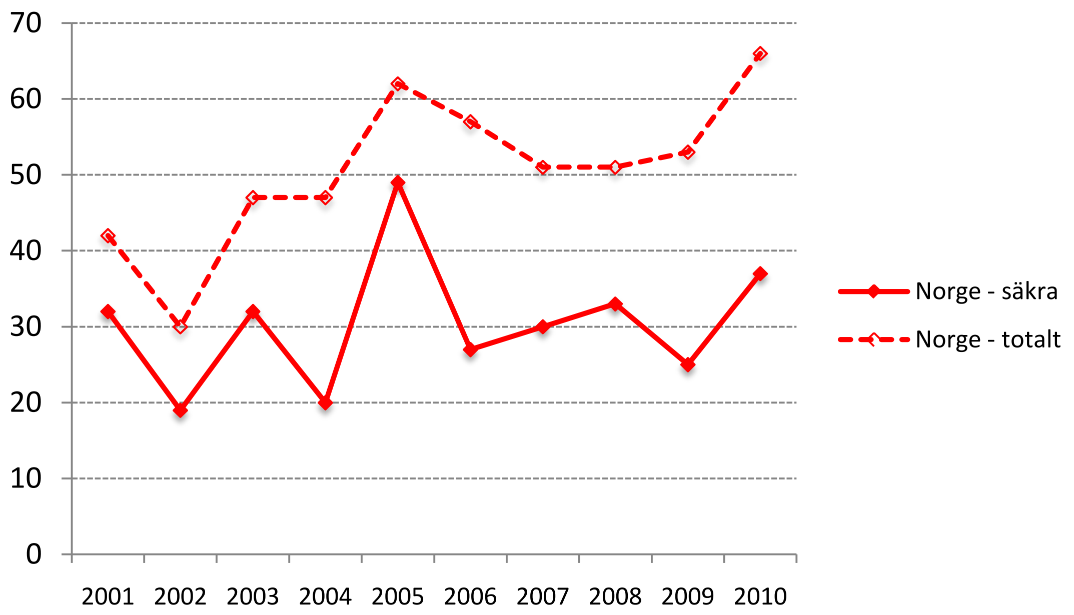
Säkra och sannolika föryngringar

Sedan 2003 i Sverige och 2001 i Norge skiljer man på säkra och sannolika föryngringar. En föryngring bedöms som säker om det har gjorts spår- eller synobservation av ungar vid en lya eller i dess närhet, eller om en järvunge har påträffats död vid lyplats. En föryngring bedöms som sannolik om man inte observerat ungar eller spår av ungar, men ett antal definierade kriterier har uppfyllts (se ex. Brøseth och Andersen 2009). Dessa kriterier har dessutom förändrats flera gånger sedan 1996 i Sverige, men inte i Norge. Följaktligen ger antalet säkra föryngringar mer tillförlitlig information om minsta antalet föryngringar i populationen och skulle kunna ses som en säkrare indikation på att en observerad trend motsvarar en förändring i populationen (antal föryngringar) snarare än förändringar i kriterierna för hur en föryngring bedöms som sannolik.

Antalet säkra föryngringar i Sverige och Norge följer samma utveckling som totala antalet, med sannolika föryngringar inkluderade (**figur 8, 9**). Framförallt gäller detta i Sverige där antalet säkra föryngringar 2008 och 2010 var högre än det totala antalet föryngringar något av åren 1996-2007. Detta kan ses som en försäkran om att den observerade ökningen av antalet föryngringar är verklig.



Figur 8*. Totalt antal registrerade järvföryngringar (säkra och sannolika) i Sverige 2003-2010 (streckad blå linje), samt antal registrerade säkra föryngringar i Sverige 2003-2010 (heldragen blå linje).*



Figur 9*. Totalt antal registrerade järvföryngringar (säkra och sannolika) i Norge 2001-2010 (streckad röd linje), samt antal registrerade säkra föryngringar i Norge 2001-2010 (heldragen röd linje).*

Uppdelning av delpopulationer

Traditionellt har man vanligen delat upp den skandinaviska järvpopulationen mellan Sverige och Norge, mellan län och fylken eller mellan förvaltningsområden i respektive land. Men det är lämpligare att se populationen som en till stora delar gemensam skandinavisk population som, baserat på genetiska data, kan delas upp i delpopulationer. Flagstad m fl. (2009) redovisar en uppdelning i tre delpopulationer: 1) En huvudpopulation som inkluderar järvar i sydöstra Norge öster om riksväg 3 i Østerdalen upp till Trondheim (delar av Hedmark och Sør-Trøndelag fylke), Nord-Trøndelag och Nordland fylken, samt hela den svenska populationen från Dalarna i söder upp till norra Norrbotten, 2) Sydvästra Norge väster om Østerdalen, samt 3) Nord-Norge (Troms och Finnmark).

Delpopulationen i sydvästra Norge skiljs från huvudpopulationen av Østerdalen, som ser ut att fungera som en spridningsbarriär för järvar. Denna delpopulation har begränsat utbyte med individer från huvudpopulationen i öster och har visat sig vara genetiskt skild från järvar öster om Østerdalen. Delpopulationen i sydvästra Norge är den minsta och troligen mest sårbara av de tre delpopulationerna (Flagstad m fl. 2009). Man dokumenterade 55 individer och beräknade att denna delpopulation bestod av knappt 70 individer 2009 (baserat på DNA). Detta är en minskning med 32 % från 2008 (Flagstad m fl. 2009). Samtidigt har antalet föryngringar under de senaste 5 åren varierat mellan 9 och 14 med den högsta siffran 2010. Om man ser på utbredningen av föryngringar i södra Norge kan man anta att den sydnorska delpopulationen kommer att växa samman med huvudpopulationen och att de genetiska skillnaderna på sikt kan raderas ut.

Delpopulationen i Nord-Norge (Finnmark och delar av Troms samt norra Finland) är genetiskt skild från huvudpopulationen i söder, även om det har dokumenterats viss invandring från söder (Flagstad m fl. 2007, 2008). Dessutom har analyser visat att den genetiska variationen hos järvar i Troms och Finnmark är ca 20 % lägre än hos järvar i Norrbotten och Västerbotten, vilket kan tyda på att populationen i Nord-Norge varit relativt liten under lång tid. Särskilt i perifera delar av utbredningen har man sett en betydande grad av inavel.

Beträffande ”skogsjärvspopulationen” i Västernorrlands och Gävleborgs län visade analyser av DNA-material, insamlat till och med 2005, att de flesta järvarna i Västernorrlands och Gävleborgs skogsland var nära besläktade och hade rekryterats från föryngringar i just denna population och härstammade från två-fyra individer (Hedmark och Ellegren 2007). Men de senaste åren har antalet järvföryngringar i Jämtland ökat framförallt i östra delarna av länet. Det innebär att avståndet mellan huvudpopulationen och denna delpopulation minskat, eller att vi nu har en kontinuerlig utbredning av järv från Jämtlandsfjällen ner till skogslandet i Västernorrlands och Gävleborgs län.

Kommentarer kring populationsutvecklingen

Populationsstorlek

Inventeringsdata visar att den totala skandinaviska järvpopulationen har ökat sedan 2000-talets början. Både i Sverige och i Norge registrerades under 2010 det högsta antalet föryngringar sedan inventeringarna startades och därmed naturligtvis även för Skandinavien som helhet (**figur 3**). I Sverige visar inventeringsdata på en generell ökning av järvpopulationens storlek sedan början av 2000-talet. Två (2008 och 2010) av de senaste tre åren registrerades de högsta antalen järvföryngringar sedan inventeringarna startades 1996. Även i Norge har antalet registrerade föryngringar ökat sedan 1996.

Det bör noteras att nivån på antalet föryngringar i Norge är i konflikt med det nationella målet för populationen (39 årliga föryngringar; St.meld. nr. 15 [2003-2004]). Det innebär att det vi kan förvänta oss att den norska delen av populationen kommer att minska, dvs. avsikten är att

minska stammen genom ett ökat uttag av individer via licensjakt och skyddsjakt. Om den norska delen av den skandinaviska järvpopulationen minskas ner till 39 föryngringar kommer det sannolikt även att ha negativ effekt på tillväxten i den svenska delen av populationen.
Om vi ser separat på de olika delpopulationerna så är det uppenbart att huvudpopulationen, dvs. hela Sverige och delar av Norge, uppvisar en positiv populationsutveckling. Delpopulationen i Nord-Norge (Troms och Finnmark) har varit stabil eller ökat sedan början av 2000-talet. Även om sydnorska populationen väster om Østerdalen består av relativt få individer så har den också uppvisat en generell ökning sett över hela perioden. Under de senast fem åren har antalet föryngringar i detta område varit relativt stabilt mellan 9 och 14 årliga föryngringar.

Utbredning

De senaste åren har utbredningen av den skandinaviska järvpopulationen ökat. I Sverige har järvpopulationen under 2000-talet ökat både med avseende på antalet föryngringar och utbredningen av dessa (**figur 1a-e, 3**). Förutom en generell expansion har det framförallt skett en expansion av föryngringar i östra delarna av Jämtland. Dessutom har antalet observationer utanför det huvudsakliga "reproduktionsområdet" ökat, vilket indikerar en expansion av järvstammen i Sverige. Denna ökning gäller såväl de östra delarna av renskötselområdet, samt i län utanför renskötselområdet (Västernorrland, Gävleborg och Dalarna).

I Norge har det huvudsakligen skett en ökning av utbredningen i södra och mellersta delarna av landet. I Hedmark fylke har populationen ökat åt söder och österut i skogslandet. Samtidigt har det skett en ökning söderut och i Trøndelag (Nord- och Sør) som har medfört att utbredningen har blivit mer sammanhängande norrut, jmf utvecklingen i Jämtland.

Faktorer som har påverkat den observerade populationsutvecklingen

Inventeringen av järvpopulationen i Sverige och Norge baseras huvudsakligen på registrering av (säkra och sannolika) föryngringar. Det innebär att man inventerar en del av populationen (honor som reproducerar sig och behåller ungarna tillräckligt länge för att lyplatser kan dokumenteras) som varierar mellan år mer än var populationen som helhet gör. Det finns alltså en "inneboende" variation i populationen som påverkar inventeringsresultaten. Dessutom kan inventeringsinsatsen variera mycket mellan år på grund av skillnader i snö- och väderförhållanden. Effekten av detta blir att inventeringsresultatet kan variera mellan år på ett sätt som inte avspeglar verkliga förändringar i populationsstorlek. Denna skillnad är sannolikt större ju mindre inventeringsområde man tittar på. Sammantaget kan man säga att det är svårt att tolka kortsiktiga populationstrender utifrån inventering av lyor eftersom förändringar mellan enstaka år snarare avspeglar variation i reproduktionsframgång och inventeringseffektivitet, än verkliga förändringar i populationsstorlek. Däremot kan avspeglas långsiktiga förändringar bättre av denna typ av inventeringar.

I anslutning till tolkningen av populationsutvecklingen är det också viktigt att notera att föreskrifterna för inventeringarna i Sverige har förändrats flera gånger (jmf. NSF 2004:17, NSF 2004:18 samt NSF 2007: 10), vilket kan på verka bedömningen av vad som klassificeras som en föryngring under olika perioder.

Det finns ett antal faktorer som tillsammans kan förklara att antalet registrerade föryngringar har ökat i Skandinavien. En naturlig orsak är naturligtvis att populationen har ökat, framförallt i Sverige, som en följd av ökad reproduktion och/eller överlevnad. Utvecklingen av järvpopulationen kan även påverkas av omfattning och effektivitet i inventeringar. Mycket talar för att inventeringsinsatsen har ökat i både Sverige och Norge sedan 1996. Förenklat kan man säga att ju mer man letar desto mer finner man, dvs. en ökad insats kan innebära att man finner en större andel av de föryngringar som sker. Om insatsen ökar kan det innebära att storleken på den observerade ökning inte är riktigt sann, dvs. man underskattade antalet föryngringar under början av perioden. Samma effekt kan fås av att inventeringspersonalen ökar sin kunskap och erfarenhet av att inventera järvföryngringar. I takt med att man får erfarenhet av platser där chansen är störst att finna föryngringar och att personalens kunskap om hur man letar föryngringar ökar blir inventeringarna effektivare. Effekten blir då samma som av en ökad intensitet i insats. Dessa faktorer har sannolikt störst betydelse i områden där man inte registrerade föryngringar under början av perioden och kanske har störst effekt på den dokumenterade utbredningen, men naturligtvis då även på antalet föryngringar.

Det är svårt att avgöra den relativa betydelsen av dessa olika faktorer. Det är sannolikt så att populationen har ökat, framförallt i Sverige, men att ökad insats och effektivitet i inventeringar innebär att ökningen kanske inte varit så stor som den ter sig.

Utbyte av individer mellan delpopulationer och kunskapsbehov

Om vi betraktar den Skandinaviska (svenska och norska tillsammans) populationen som en enhet måste vi beakta omfattningen av utbyte med finska och/eller ryska järvar och då är situationen mer oklar. I dagsläget är det inte sannolikt att genetiska problem utgör ett hot för den skandinaviska järvpopulationen. På lång sikt är det dock betydelsefullt att tillförsäkra kontakt med järvar i Finland och Ryssland i öster. Mest sannolikt sker ett eventuellt utbyte via Nord-Norge (primärt Finnmark fylke) och norra Sverige där järvstammen emellertid är relativt gles, varför eventuellt utbyte förmodligen sker i begränsad omfattning, vilket antyds av de analyser som visar att järvar i Finnmark och Troms skiljer sig genetiskt från övriga järvar i Skandinavien och att man vinetern 2006/2007 inte identifierade några invandrare från Finland/Ryssland (Flagstad m fl. 2007). Flagstad m fl. (2009) visade också att järvarna i norra Finland bör räknas in i den nordnorska populationen.

Det bör vara prioriterat i skandinavisk järvförvaltning att öka kunskapen om i vilken grad den skandinaviska populationen har kontakt med östligare populationer. I tillägg bör man analysera populationsuppskattningar och beräkning av demografiska parametrar för olika delar av populationen baserat på insamling och analys av DNA-material för hela den skandinaviska populationen. Speciellt viktigt är eventuella skillnader i vuxenöverlevnad och utbyte av individer mellan områden, eftersom det är stora skillnader mellan Sverige och Norges strategier för hur den gemensamma skandinaviska populationen förvaltas.

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Bilaga 1

Historisk utbredning i Sverige

Kunskapen om järvens utbredning före 1800-talet är mycket liten. Dock uppgav Olaus Magnus att den under 1500-talet förekom i de nordligaste delarna av Sverige. Enligt både Ekman (1910) och Lönnberg (1936) hade järven under 1800-talet, liksom idag, sin huvudsakliga utbredning i renskötselområdets fjäll- och skogstrakter. Även då var antalet järvar högst i Norrbotten, lägre i Västerbotten och ännu lägre i Jämtland. I Norrbotten gick den östra gränsen för utbredningen ganska nära kusten även om de flesta järvarna fanns i fjällen och de fjällnära skogarna.

Enligt fångststatistik från 1827-1934 hade järven under denna period en större geografisk utbredning än idag och återfanns i Värmland och Dalarnas skogstrakter i relativt små stammar. Söderut fångades enstaka järvar så långt ner som i Skåne, Blekinge och Småland. Fångster och observationer av järvar söder om Värmland rörde sig sannolikt om enstaka utvandrade järvar. Värmland är troligen det sydligaste landskap som hyst en fast järvstam. Under 1800-talet började dock järven försvinna från Värmland och under mitten av seklet var stammen troligen borta från Värmland. Dalarna hade troligen en liten men fast järvstam som troligen försvann under mitten av 1800-talet. Järvens förekomst i Gävleborgs län under 1800-talet är oklar, men mycket tyder på att järvens förekomst i länet var av sporadisk natur. Enligt Ekman ansågs järven ha försvunnit från Västernorrland under början av 1900-talet, där den tidigare hade varit förekommande, framförallt i Ångermanlands nordvästra bergstrakter.

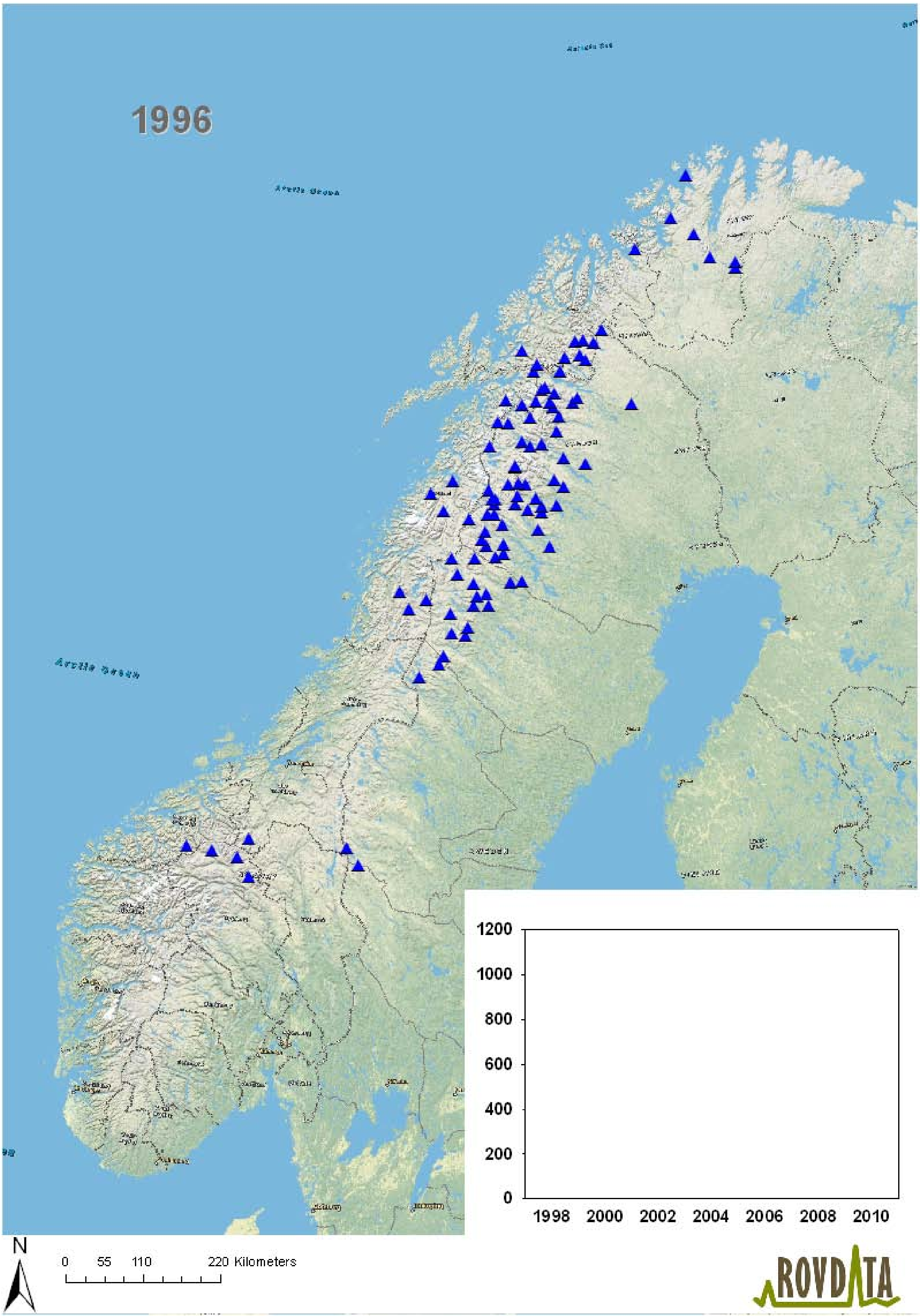
Det förefaller som att järvstammen påverkades starkt av mänsklig förföljelse redan under tidigt 1800-tal. Därför kan befintlig information om historisk utbredning underskatta järvens tidigare utbredning i söder eftersom järvens utbredning minskade från söder mot norr redan för över 200 år sedan. Huvudintrycket är dock ändå att järvstammens utbredning i söder haft sin gräns i Värmland och Dalarna. Under 1930-talet hade sydgränsen förskjutits till mellersta Härjedalen. Av intresse är att den beskrivna kunskapen om järvens historiska utbredning stämmer relativt väl överens med en nutida analys av tillgång och utbredning av lämplig järvmiljö på den skandinaviska halvön.

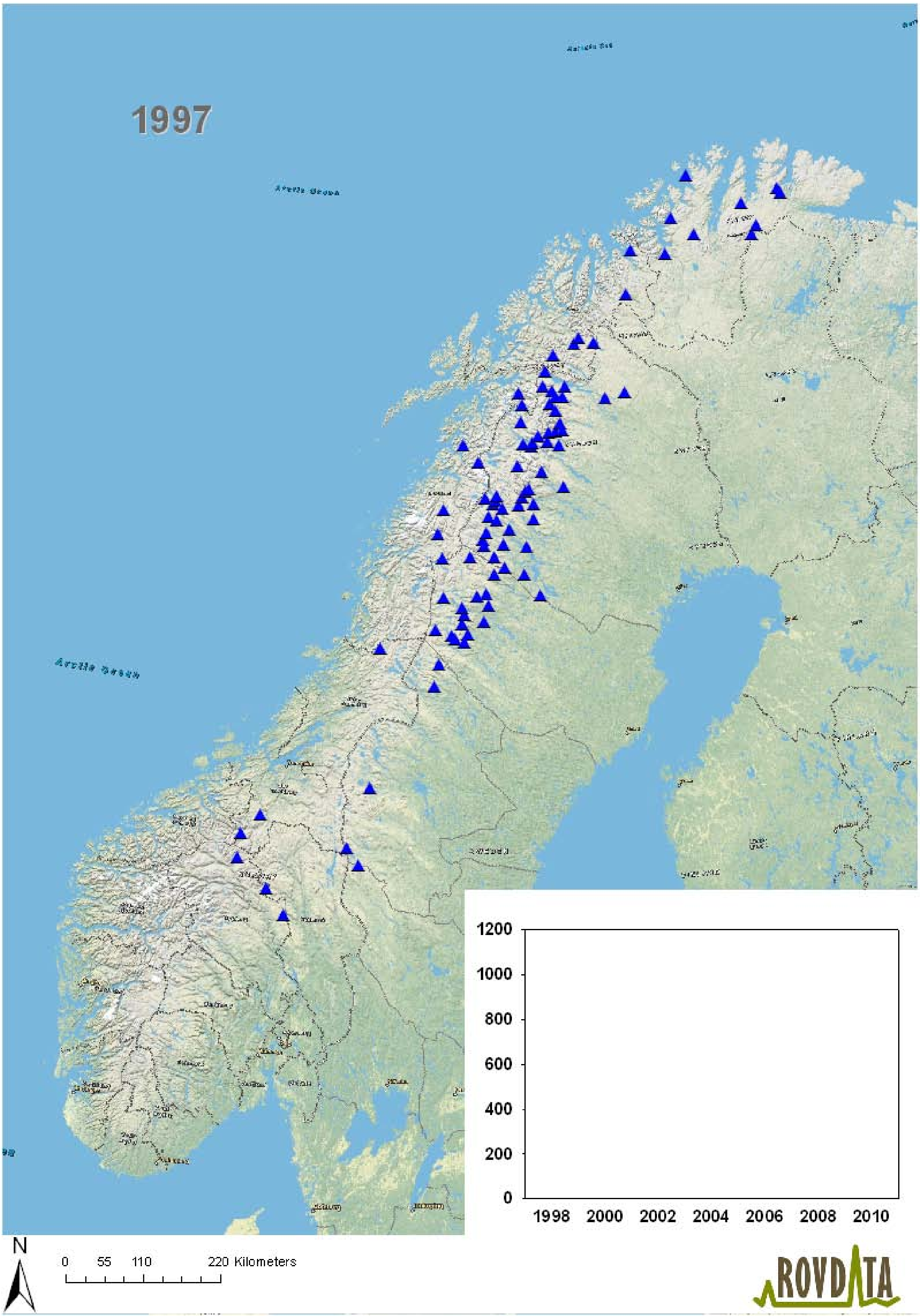
Enligt Haglund (1965) fortsatte järvstammen att minska under 1900-talet, främst till följd av ökade möjligheter till jakt på grund av förbättrade kommunikationsmöjligheter. Haglund uppskattade under 1960-talet att: ”Antalet levande järvar inom landet torde knappast överskrida etthundra exemplar.” Troligen är det lägre. Det är ytterst tvivelaktigt om mer än tio kullar i hela landet går fram per år”.

När vi använder äldre källor för att förstå utbredning och förekomst av rovdjur i ett historiskt perspektiv är det viktigt att notera osäkerheten i dessa uppgifter. Även idag med ett stort antal inventerare med relativt stora resurser till sitt förfogande råder osäkerhet kring bedömningar av populationsstorlek. Därför ska historiska uppgifter användas med försiktighet. Men de kan ändå ge en förståelse av de stora dragen hos tidigare populationsförändringar och utbredning.

Bilaga 2

Järvföryngringar i Skandinavien 1996-2010. Underlag för online tilläggsmaterial:
www.youtube.com/watch?v=0geRd8iXKHg

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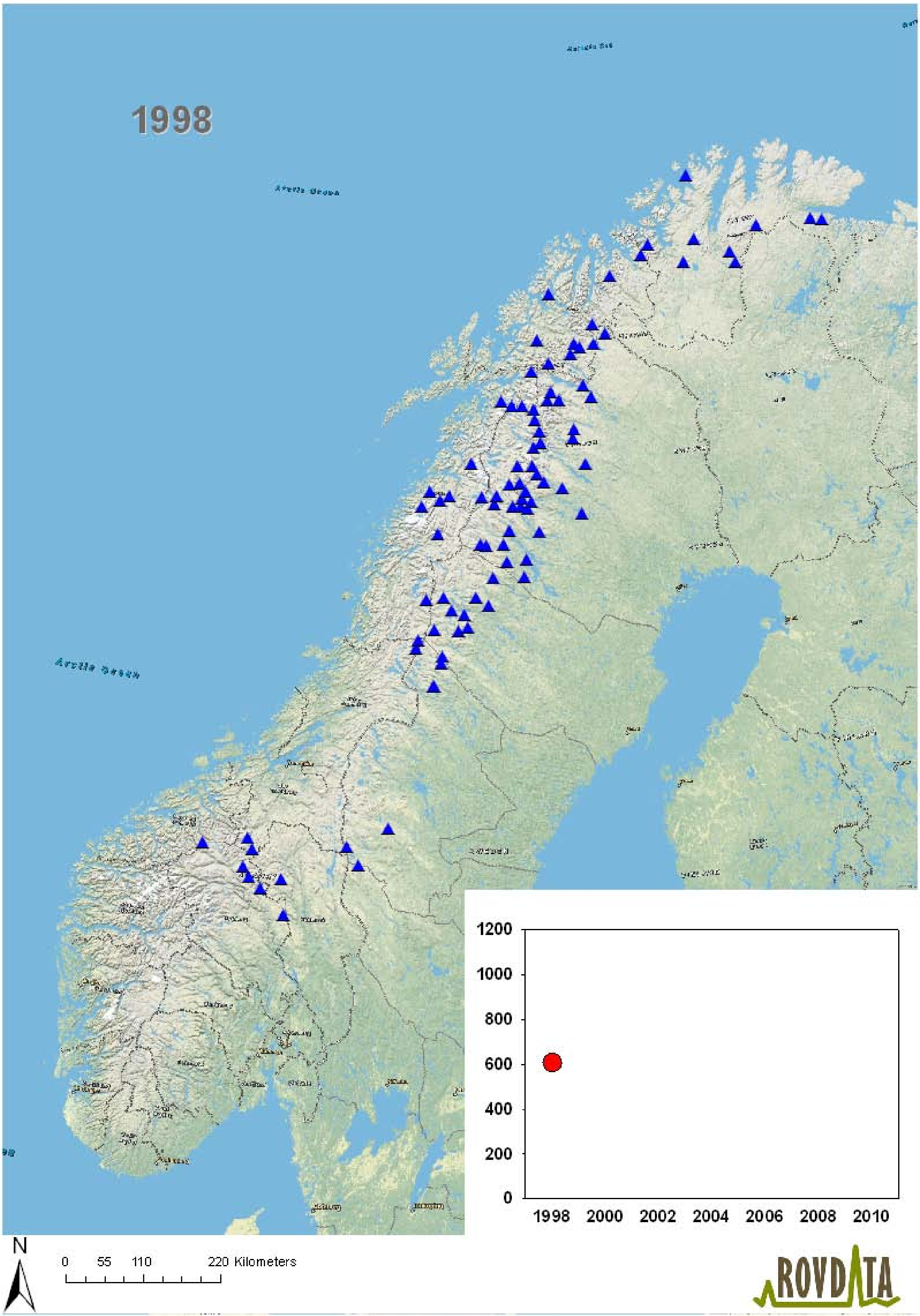
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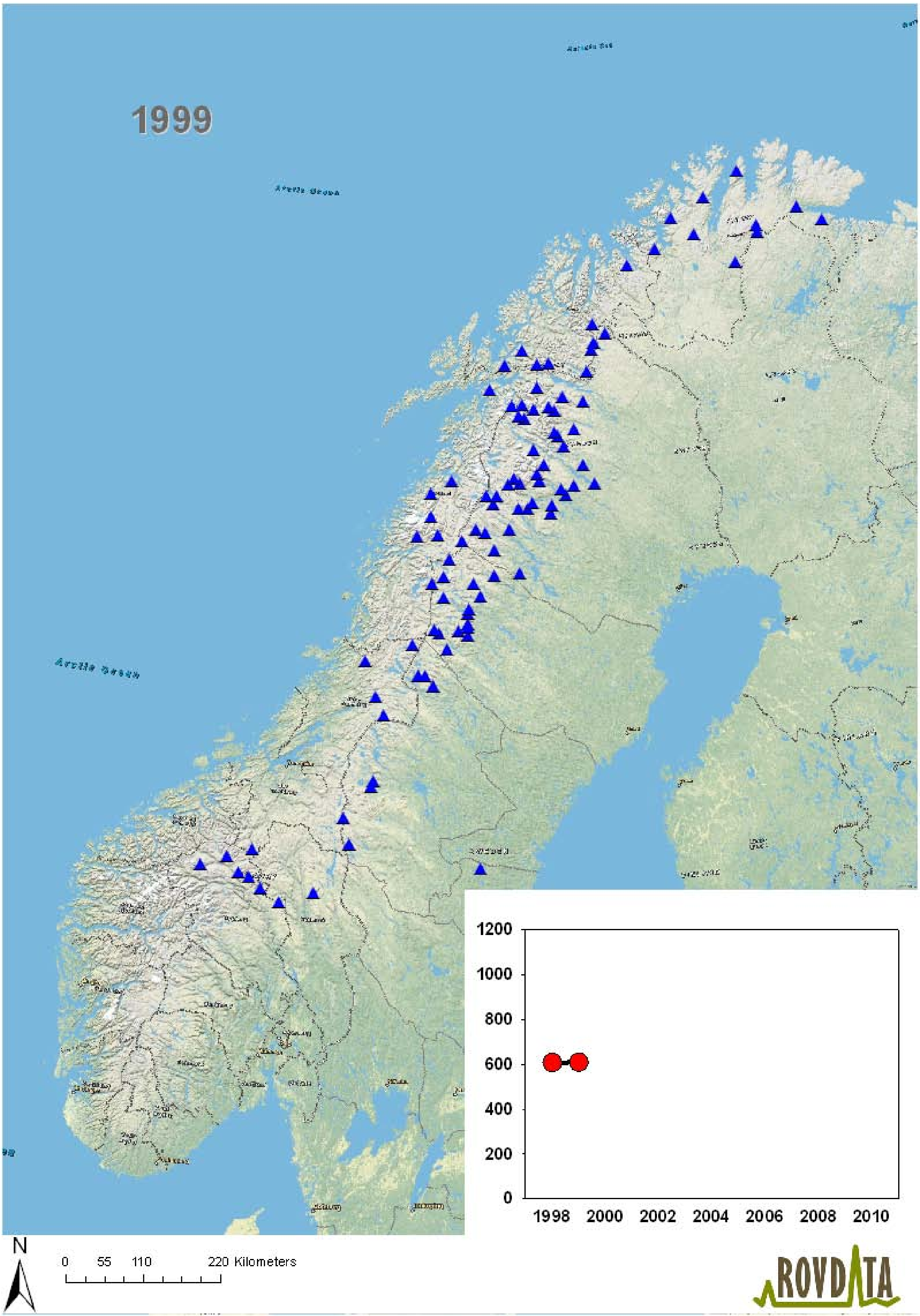
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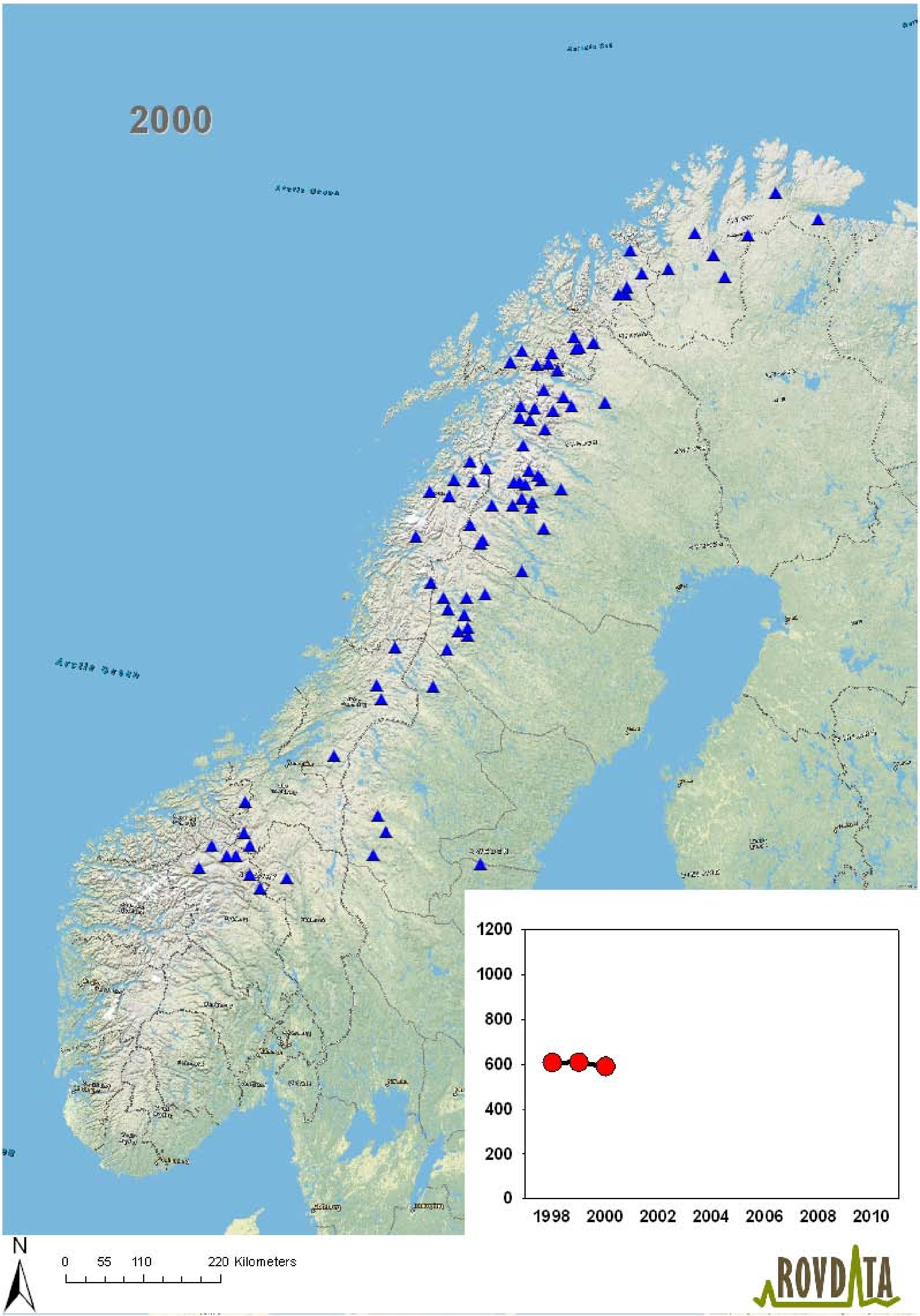
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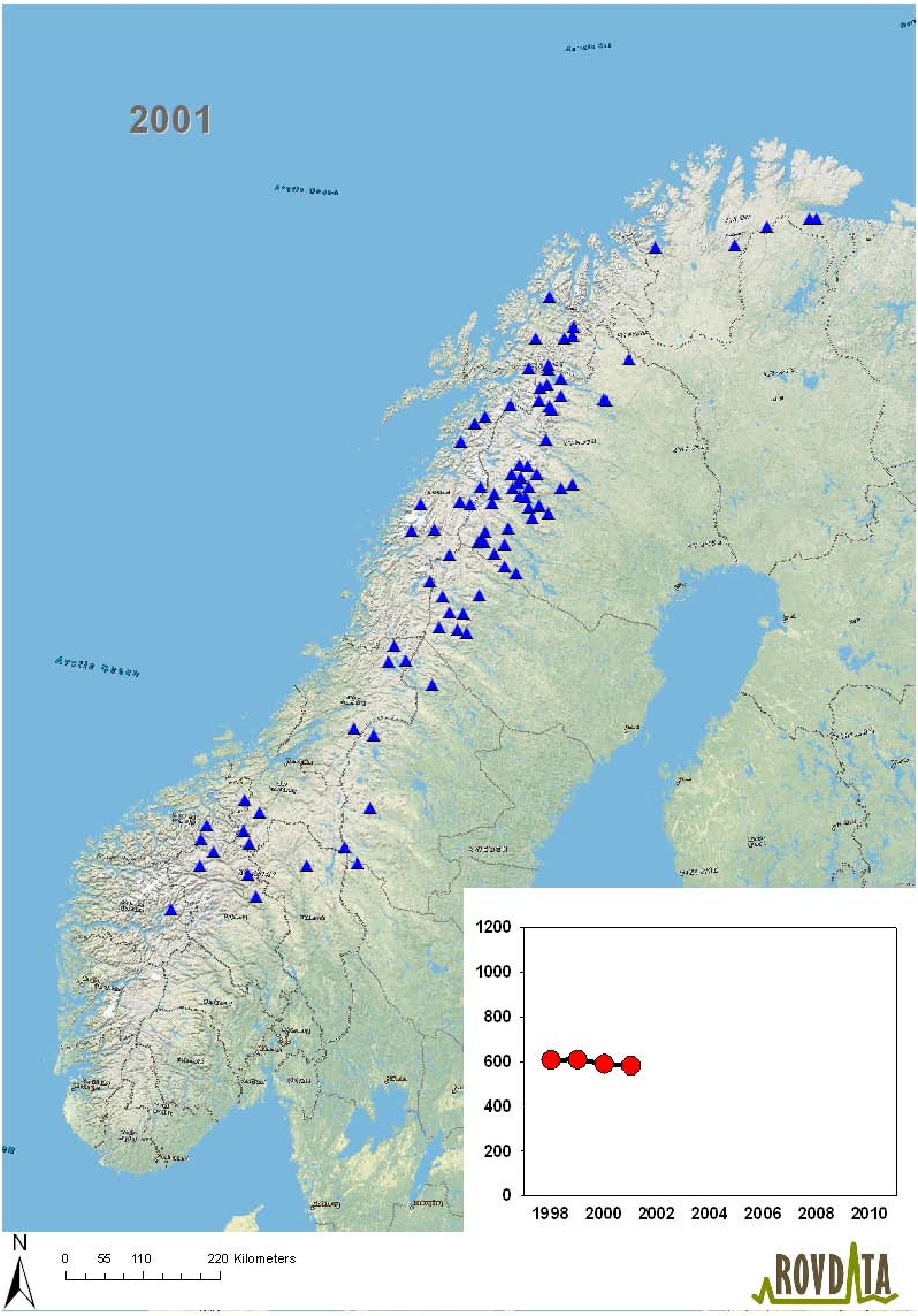
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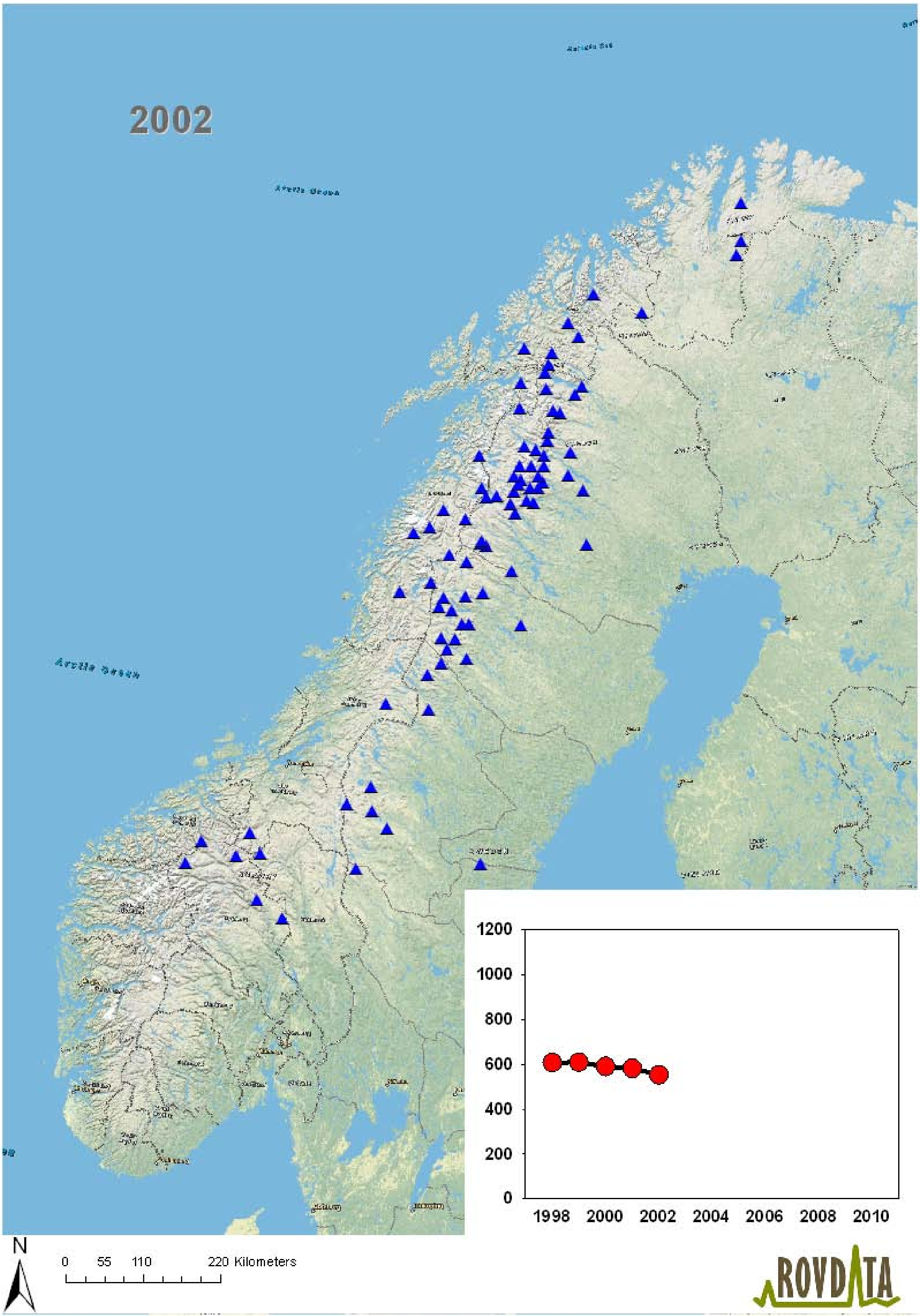
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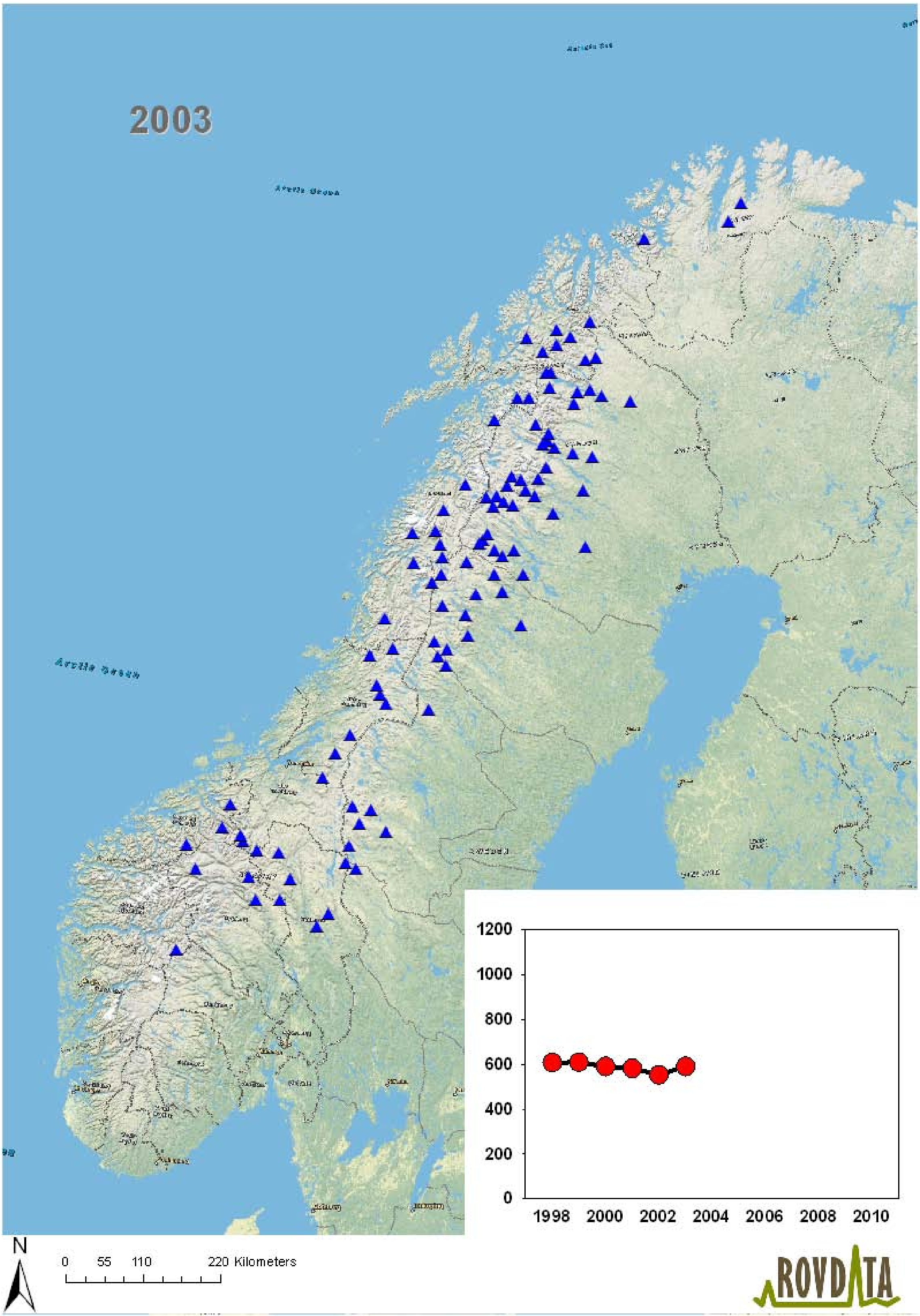
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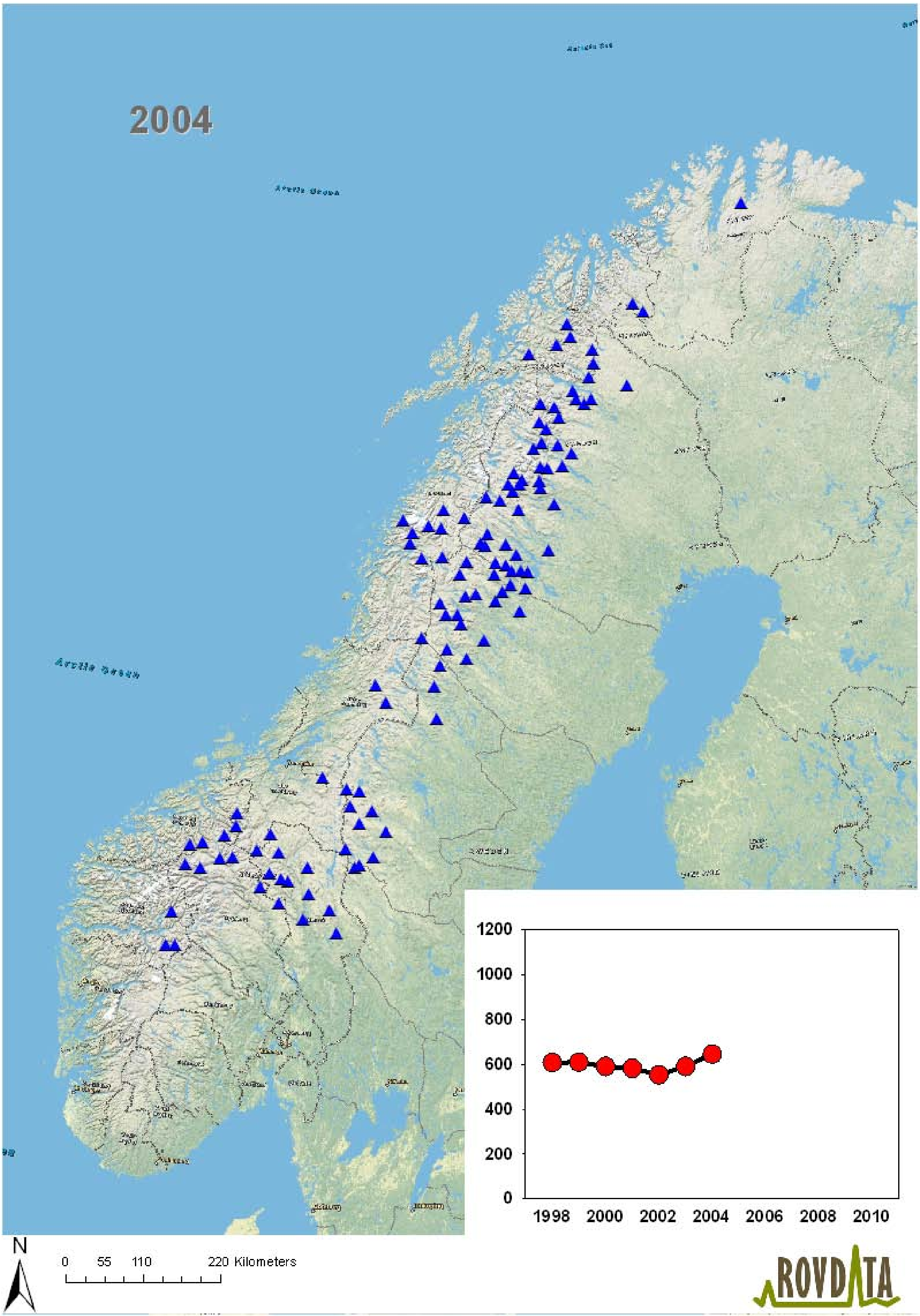
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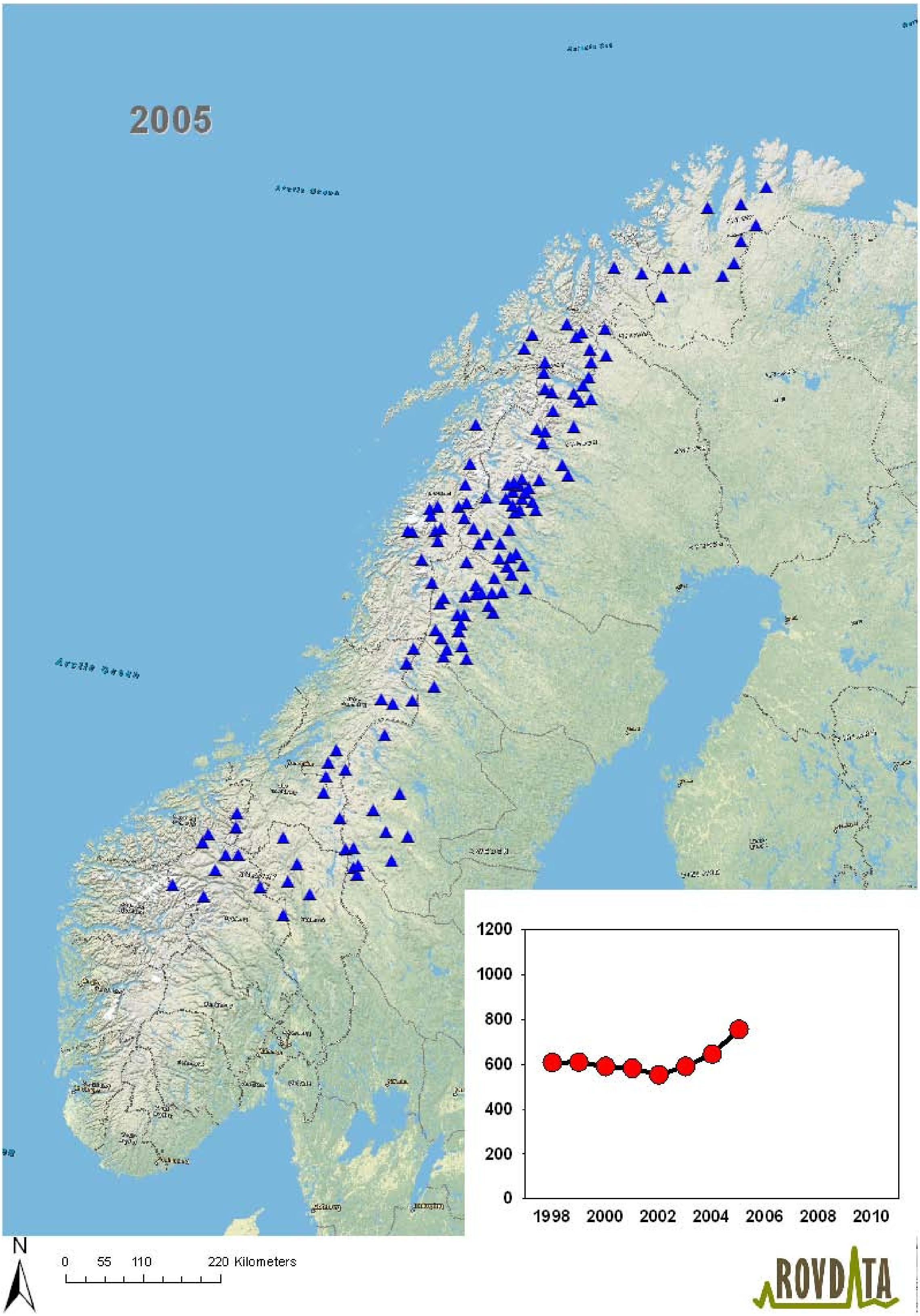
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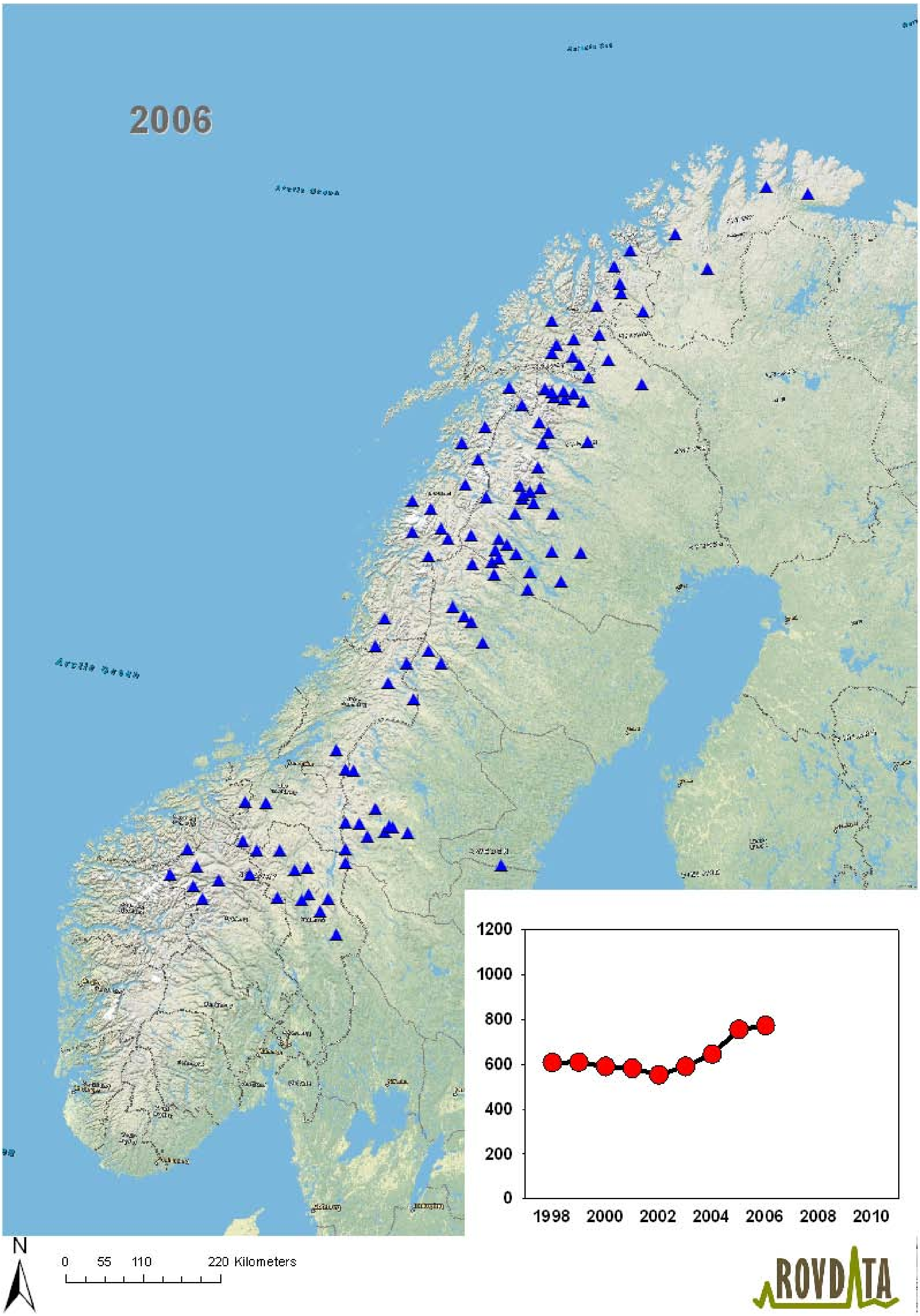
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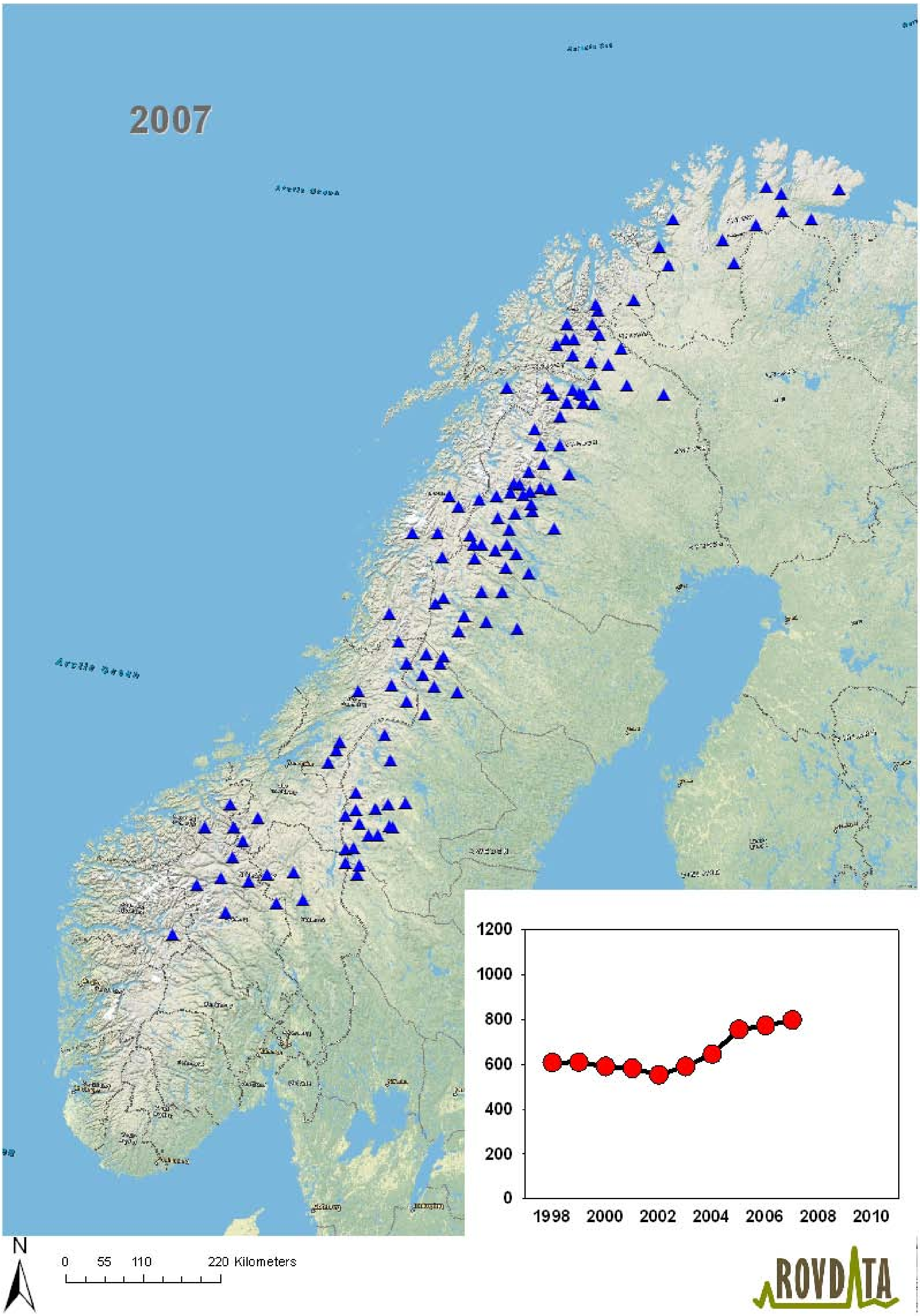
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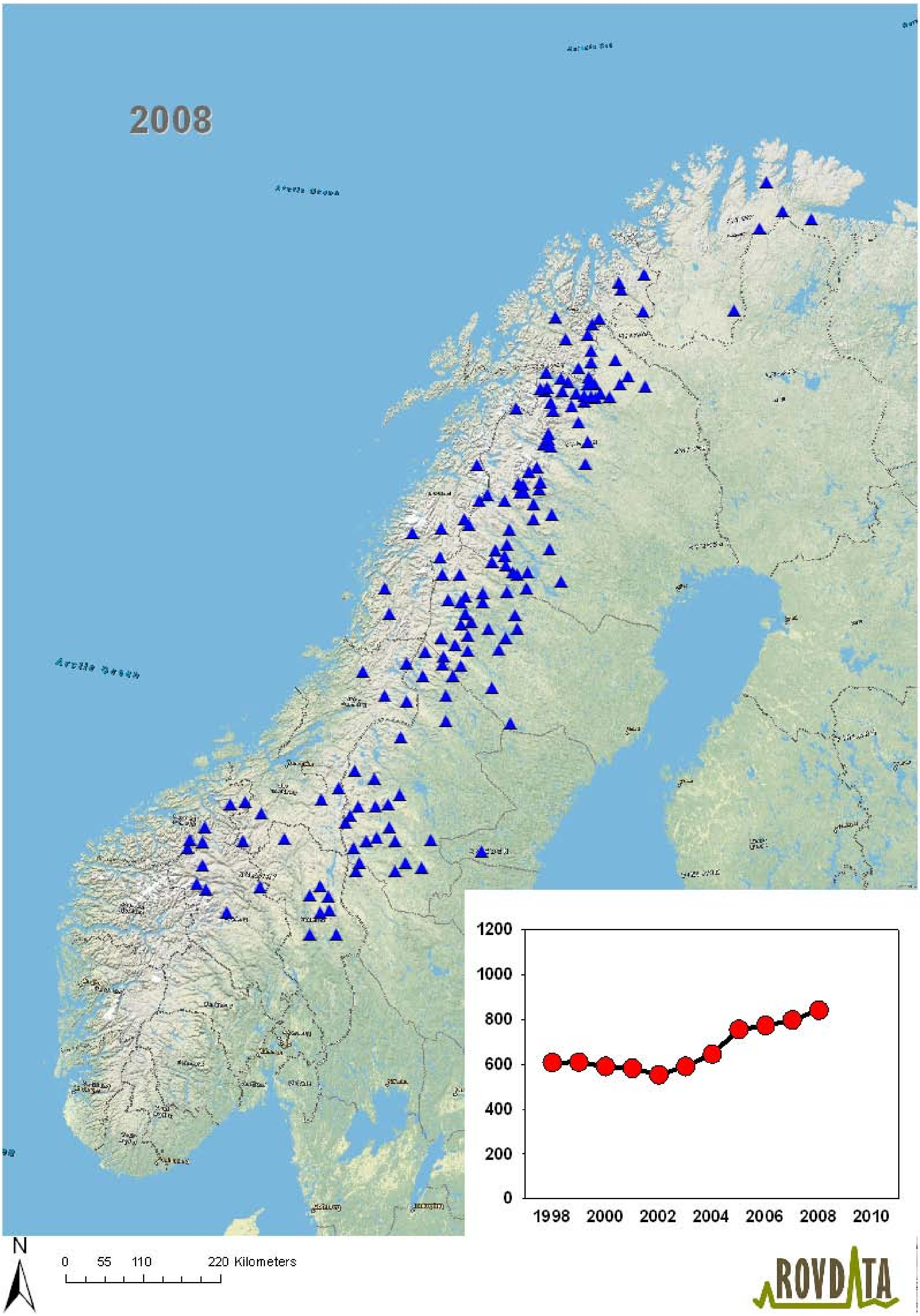
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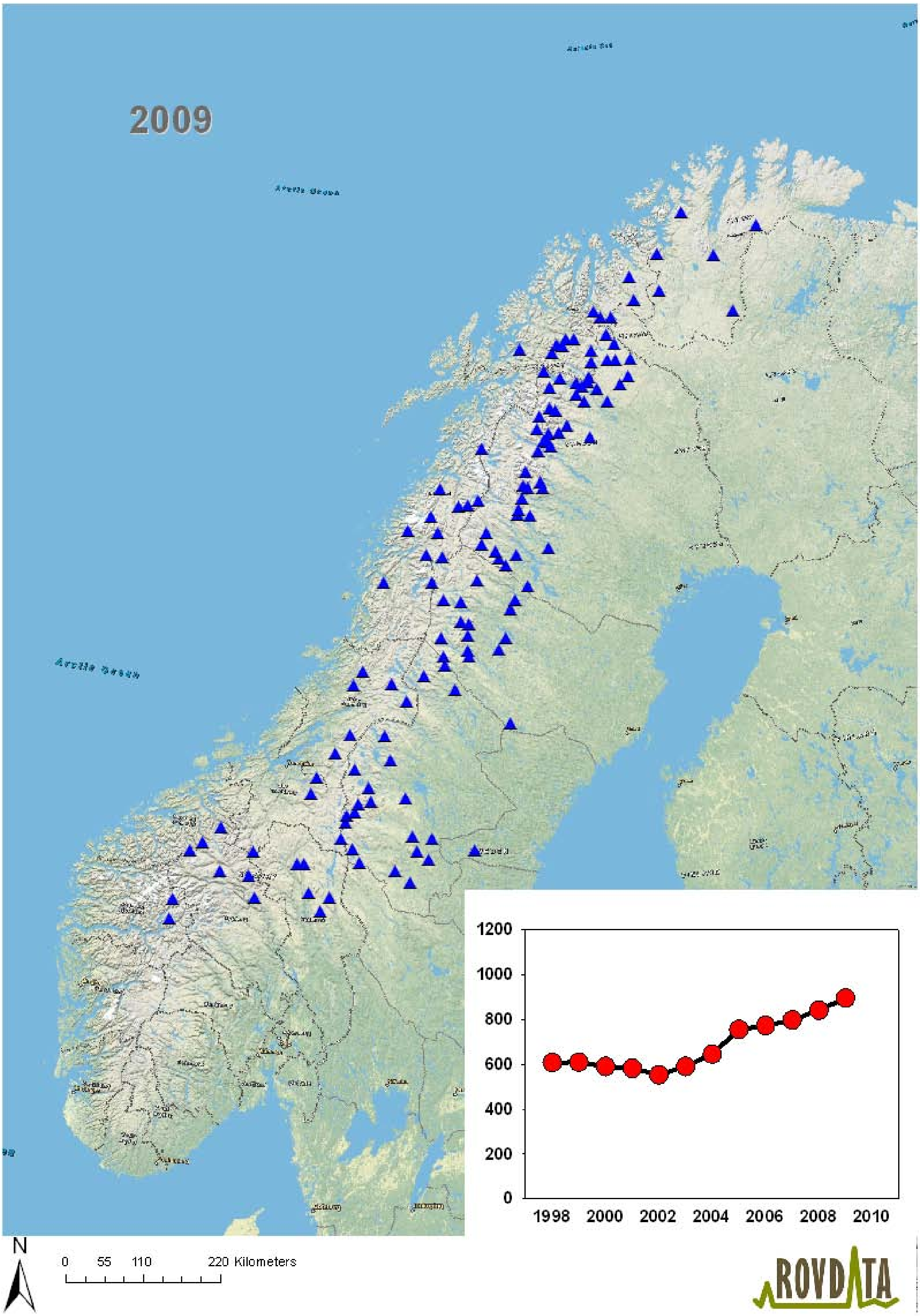
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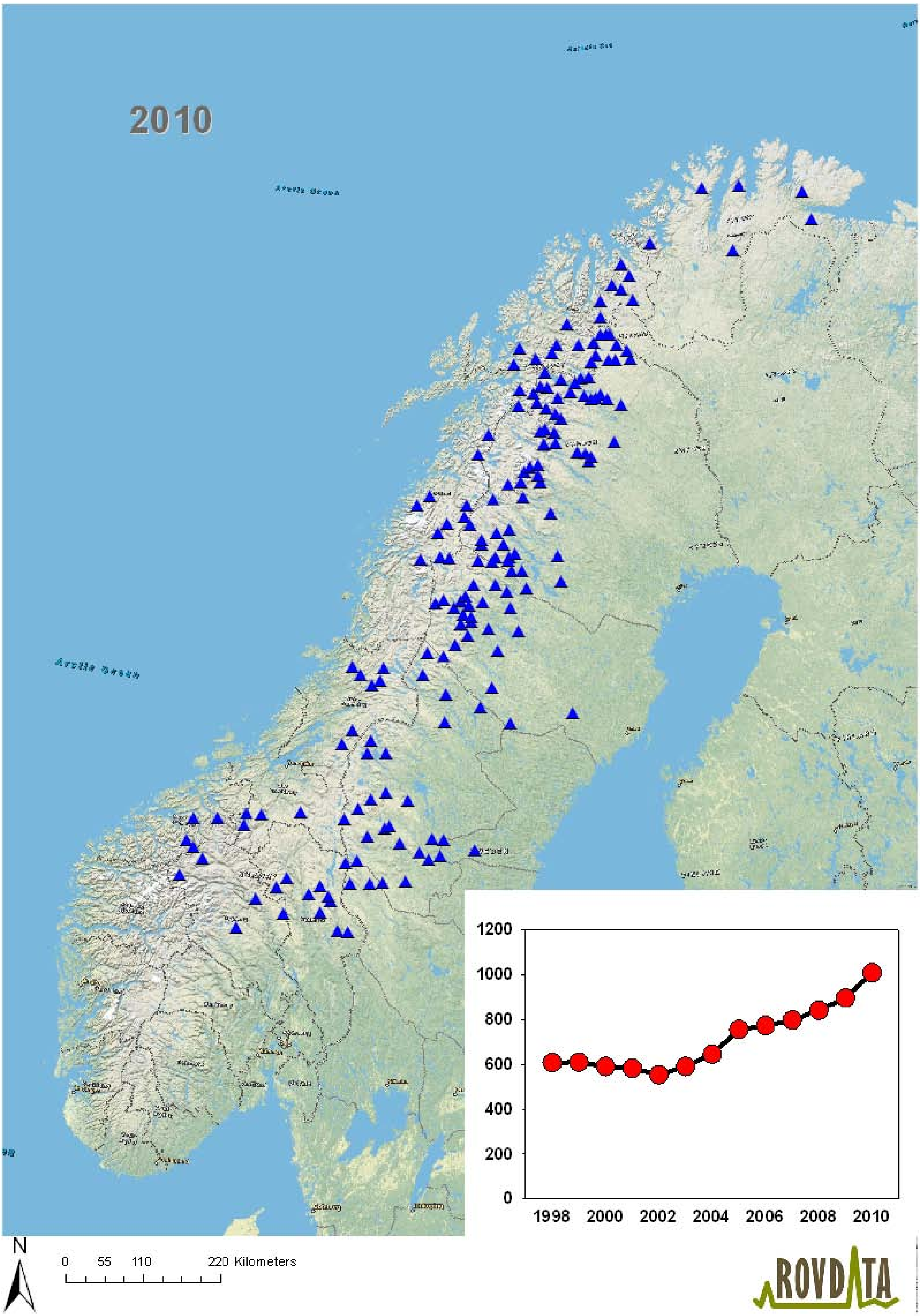
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Norsk institutt for naturforskning
NINA Hovedkontor
Postadresse: Postboks 5685 Sluppen, NO-7485 Trondheim
Besøks/leveringsadresse: Tungasletta 2, NO-7047 Trondheim
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Samarbeid og kunnskap for framtidas miljøløsninger

From: Shoemaker, Justin
To: Snyder, Caitlin
Cc: Grizzle, Betty
Subject: Re: Revised wolverine timeline-draft
Date: Tuesday, June 13, 2017 2:49:56 PM

I'll revise the timeline. Thanks.

Justin Shoemaker
Classification Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

On Tue, Jun 13, 2017 at 3:46 PM, Snyder, Caitlin <caitlin_snyder@fws.gov> wrote:

> Hi Justin,
>
> 50 CFR 424.16 directs us to open a comment period of 60 days on any rule proposing the listing, delisting, or reclassification of a species. If we issue a revised proposed rule for wolverine, it isn't totally clear that this would require 60 days, but given the interest in the species, the time between the original proposal and revised proposal, and the fact that we will have an SSA with new analyses/information, it would behoove us to do a 60 day comment period. I checked with Q and she agrees it makes sense to do 60 days.
>
> Thanks,
> Caitlin
>
> Caitlin Snyder
> Unified Listing Team
> U.S. Fish & Wildlife Service
> MS: ES
> 5275 Leesburg Pike
> Falls Church, VA 22041-3803
> phone: 703 358 2673
>
> On Thu, Jun 8, 2017 at 2:41 PM, Shoemaker, Justin <justin_shoemaker@fws.gov> wrote:
>
>> Caitlin,
>>
>> Can you check if the comment period will need to be 60 days for wolverine?
>>
>> Justin Shoemaker
>> Classification Biologist
>> U.S. Fish and Wildlife Service, Region 6
>> Phone: 309-757-5800 x214
>> Email: justin_shoemaker@fws.gov
>>
>> On Wed, May 24, 2017 at 3:27 PM, Snyder, Caitlin <caitlin_snyder@fws.gov> wrote:
>>
>>> Hi Justin,
>>>
>>> I changed a few of the dates in the HQ review chain based on the FR submittal

dates. Let me know if you have any questions. (I did account for the public holiday in September for the final action when calculating dates.)

Thanks,
Caitlin

Caitlin Snyder
Unified Listing Team
U.S. Fish & Wildlife Service
MS: ES
5275 Leesburg Pike
Falls Church, VA 22041-3803
phone: 703 358 2673

On Wed, May 24, 2017 at 1:56 PM, Shoemaker, Justin <justin_shoemaker@fws.gov> wrote:

> Caitlin,
>
> Here's my attempt at a revised schedule for wolverine. Can you look over the HQ review time frames for this schedule?
>
> I still need to go over the dates currently in there to make sure they don't fall on weekends or holidays.
>
> Justin Shoemaker
> Classification Biologist
> U.S. Fish and Wildlife Service, Region 6
> Phone: 309-757-5800 x214
> Email: justin_shoemaker@fws.gov

From:	Grizzle, Betty
To:	A J
Subject:	Re: Article on measuring snowpack
Date:	Wednesday, June 14, 2017 10:09:53 AM

No later than early September.

On Wed, Jun 14, 2017 at 9:00 AM, A J <222wsheridan@gmail.com> wrote:

> Betty
> By what date would you need to receive the Swedish den data relative to the snow model? That may make a difference to Jens/Malin.
> Thanks
> Audrey
>
> Sent from my iPhone
>
> On Jun 13, 2017, at 8:58 AM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
>
> I will try again to reach out to Malin, but she did not respond to my life expectancy question that I sent last month.
>
> On Mon, Jun 12, 2017 at 9:49 AM, A J <222wsheridan@gmail.com> wrote:
>
>> I have seen an older map she prepared awhile ago in one of her reports but I haven't seen any recent version with all the more recent dens. I'm fairly certain Jens or Malin could produce this but my understanding from Jens was that you did not think you could use anything that has not been published. Perhaps a quick request to Jens would answer the question, preferably well before July when all of Sweden goes on holiday and emails go unanswered!
>>
>> Sent from my iPhone
>>
>> On Jun 12, 2017, at 8:22 AM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
>>
>> Thanks for your input on this.
>> I'm not able to share an exact date with you for the Species Status Assessment Report, but, according to our national workplan, we are required to submit a FR document (i.e., proposed rule) early next year.
>>
>> A quick question - Has Jens or Malin prepared a map of their den locations relative to the predictions from Copeland et al.'s snow model? I am not recalling one at the moment, but have been out of the office for the past 10 days (attending UC Berkeley class) so I need to go back through the papers that Malin sent.
>>
>> On Mon, Jun 12, 2017 at 9:05 AM, A J <222wsheridan@gmail.com> wrote:
>>
>>> Thanks, Betty. I read the original paper a little while ago. It's exciting stuff for those interested in snow and climate change

but I think it will be quite a while before snow data from this technology will be available for wolverine researchers. We looked into LIDAR for our snowdrift work on the North Slope of Alaska but the problems with scale and cost were not encouraging. For now we will stick with aerial photography in known wolverine home ranges. We photographed about 20 areas this spring on May 28/29 where snow holes were used by wolverines and we have cameras monitoring them. Spring was at least two weeks later than last year, so lots of snowdrifts remaining. By the way, Jens went out and photographed 8 or 9 wolverine dens in southern Sweden on May 16 to document structure (no snow present). I'm hoping researchers will begin to focus on just what happens to females and kits when snow begins to melt and into the following months when kits are still left at rendezvous sites.

I've been wondering if there is a date set for when USFWS will produce the status review and decision? Just curious.
Audrey

Sent from my iPhone

> On Jun 12, 2017, at 7:10 AM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
>
> Hi Audrey - I thought you might be interested in this article from yesterday's LA Times.
>
> --
>
> Betty J. Grizzle, D.Env.
> Fish and Wildlife Biologist
> U.S. Fish and Wildlife Service
> Carlsbad Fish and Wildlife Office
> 2177 Salk Ave, Suite 250
> Carlsbad, CA 92008
> 760-431-9440, ext. 215
> 760-431-5901 fax
> <Serna_LA Times Surveying snowpack _June 11 2017.pdf>

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250

> > Carlsbad, CA 92008
> > 760-431-9440, ext. 215
> > 760-431-5901 fax

> --

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Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

From: Hansen, Craig
To: Justin Shoemaker
Subject: Fwd: Surname Package: BP Memo Wolverine
Date: Monday, June 19, 2017 1:44:37 PM
Attachments: image002.png
Briefing Memo for RD_Wolverine SSA update_06122017.docx
Surname Pkg Note to Reviewer.docx
surname_list.pdf
Wolverine Detailed Timeline_06122017.docx
Surname Pkg Routing List.doc

2017-04-10_Email_Signature_3.jpg

---------- Forwarded message ----------
From: **Trina Vigil** <trina_vigil@fws.gov>
Date: Mon, Jun 12, 2017 at 12:16 PM
Subject: Surname Package: BP Memo Wolverine
To: Craig Hansen <craig_hansen@fws.gov>
Cc: John Guinotte <john_guinotte@fws.gov>, Justin Shoemaker <justin_shoemaker@fws.gov>, trina_vigil@fws.gov

Craig-

Good afternoon, can you please surname the attached surname package. Make sure to sign the Yellow Surname sheet once you have approved it please forward it to next person on the routing sheet and reply to all to allow the author and myself able to track the location of the surname package. If you make any changes to any of the documents please make the changes on the I:\drive document and attach the new version of the document to the email.

All documents can be found at the following location: I:\- Surname Word Document\Surname ES\Shoemaker\BP Wolverine

Note: Needs to be delivered to RD office today

ECOLOGICAL SERVICES		
#	NAME /TITLE/ OFFICE	LTR*
	Field Office -	F
	Backsen, Sarah	F
	Boroja, Maria	F
	Burgess, Angela	F
	Burgess, Kevin	F
	Gober, Joy	F
	Guinotte, John	F
2	Hansen, Craig	F
	Joersz, Kiana	
	Juliusson, Lara	F
	Kelleher, John/Eileen Lindgren	F
	Konishi, Kathy	F
	Laye, Doug	F
	Lickfett, Todd	F
	Norman, Kate	F
	Orton-Palmer, Amelia	F
	Sattelberg, Mark	F
1	Shoemaker, Justin	F
	Skorupa, Joe	F
	Smith, Kim	F
	Wiechman, Lief	F
3	Nelson, Marjorie/ Chief – Ecological Services	F
	Kales, Matt	F
	Vigil, Trina/Secretary/ ES	F
	Naylon, Jill/Secretary/ES	F
	Alt, Nicole/ Deputy ARD-ES	F / G
4	Thabault, Mike / ARD-ES	F / G
5	Regional Director / Deputy RD	F / G
	External Affairs	F
	Budget Administration	F
	Fisheries	F
	Law Enforcement	F
	Migratory Birds / State Programs	F
	Refuges	F
	Ecological Services	H
* F -- surname G -- signature H -- return to originating office		
FROM: Trina Vigil	DATE: 6/12/17	

Trina Vigil

Administrative Support Assistant

134 Union Blvd

Lakewood, CO 80228

(303) 236-4253

ECOLOGICAL SERVICES

#	NAME /TITLE/ OFFICE	LTR*
	Field Office -	F
	Backsen, Sarah	F
	Boroja, Maria	F
	Burgess, Angela	F
	Burgess, Kevin	F
	Gober, Joy	F
	Guinotte, John	F
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	Joersz, Kiana	
	Juliusson, Lara	F
	Kelleher, John/Eileen Lindgren	F
	Konishi, Kathy	F
	Laye, Doug	F
	Lickfett, Todd	F
	Norman, Kate	F
	Orton-Palmer, Amelia	F
	Sattelberg, Mark	F
1	Shoemaker, Justin	F
	Skorupa, Joe	F
	Smith, Kim	F
	Wiechman, Lief	F
3	Nelson, Marjorie/ Chief – Ecological Services	F
	Kales, Matt	F
	Vigil, Trina/Secretary/ ES	F
	Naylon, Jill/Secretary/ES	F
	Alt, Nicole/ Deputy ARD-ES	F / G
4	Thabault, Mike / ARD-ES	F / G
5	Regional Director / Deputy RD	F / G
	External Affairs	F
	Budget Administration	F
	Fisheries	F
	Law Enforcement	F
	Migratory Birds / State Programs	F
	Refuges	F
	Ecological Services	H

* **F** -- surname **G** -- signature **H** -- return to originating office

FROM: Trina Vigil DATE: 6/12/17

BRIEFING MEMORANDUM FOR THE REGIONAL DIRECTOR

DATE: June 12, 2017

FROM: Michael Thabault, Assistant Regional Director, Ecological Services

SUBJECT: Wolverine Species Status Assessment Update

To inform the Regional Director of the progress made on the North American wolverine (wolverine) Species Status Assessment (SSA) Report and the key information that will be of interest to the eventual wolverine listing decision. A briefing is scheduled for June 15.

BACKGROUND

In compliance with a Court order that remanded our previous withdrawal of a proposed rule to list the contiguous U.S. Distinct Population Segment (DPS) of the wolverine (79 FR 47522; August 13, 2014), we will prepare either a revised proposed rule to list or a revised withdrawal of the previous proposed rule (78 FR 7864; February 4, 2013). In October 2016, we published a notice to announce the vacature of the withdrawal rule to the public, announce the proposed status since the judge's ruling, and to reopen the public comment period on the February 4, 2013 proposed rule to list the wolverine as a threatened species.

DISCUSSION

Highlighted in Judge Christensen's Court order remanding the withdrawal were the Service's determinations regarding: (a) the threat posed to the wolverine by the effects of climate change at the reproductive denning scale, (b) the threat posed to the wolverine by small population size and lack of genetic diversity, and (c) application of the SPR Policy to the wolverine. In our SSA Report we are reviewing previously considered information and new information to inform these points to ensure we are using the best available science upon which to base our listing decision.

Range of the Species – using both previously considered and new information, we have revised our approach to delineate the range of the wolverine across North America and in the contiguous United States to more accurately represent the species' range.

Trapping Data – we have collected additional trapping data not available to us in 2014 to inform the range of the species and the effect of trapping in Canada (British Columbia and Alberta); this information is directly relevant to informing our DPS determination.

NOAA/CU snow persistence model – High resolution snow pack models have been developed for Glacier and Rocky Mountain National Parks. These areas bracket the DPS range for the wolverine in the contiguous United States. The majority of model scenarios indicate significant future snow persistence through April and May for 1) elevations currently used for denning in Glacier National Park and 2) the inferred elevations where wolverines would be expected to den in Rocky Mountain National Park.

New denning information – we have received several peer-reviewed publications and other information from wolverine researchers that were not available to us in 2014 documenting natal den sites and den site conditions that provide new insight into the timing and location of wolverine den sites; natal den sites have been documented in locations outside of areas previously predicted by Copeland et al. (2010) snow model in North America and in Scandinavia.

Population Viability Analysis (PVA) underway – we are coordinating with USGS to develop a PVA to inform minimum viable population size and to develop future scenarios that model the potential effects of demographic and habitat parameters on the wolverine population in the contiguous United States.

Genetics – The court stated that, in our 2014 withdrawal, we failed to articulate how our statements regarding the following did not constitute adverse effects to wolverine:

- Apparent loss of connectivity between Rocky Mountains and Canada prevented influx of genetic material needed to maintain or increase the genetic diversity in contiguous U.S.
- Effective population size is too low to support the subpopulations in contiguous U.S.
- Genetic drift has already occurred in subpopulations in contiguous U.S. as compared to Canada, and a continued loss of genetic diversity may lead to inbreeding depression and inability of wolverines in contiguous U.S. to persist.

To address these concerns we need to evaluate our analysis in previous rules in which we concluded that there is "good evidence" that genetic diversity is lower in wolverines in the contiguous U.S. as compared to Canada and Alaska. We also need to determine whether there is a threat for inbreeding depression based on small population size. In addition to informing these points, knowledge gained through a more thorough and complete analysis of the genetic structure of wolverine populations throughout North America would better inform our DPS determination.

NEXT STEPS

We plan to present the final SSA Report, with peer and partner review incorporated, to the RD and decision team by December 2017.

ATTACHMENTS

See attached for a schedule outlining steps and timelines for preparation of the North American wolverine SSA Report and listing decision documents.

NOTE TO REVIEWER (NTR)

DATE SUBMITTED: June 12, 2017

PREPARED BY: Justin Shoemaker, Classification Biologist, for Mike Thabault

SUBJECT: **BRIEFING MEMORANDUM ON THE NORTH AMERICAN WOLVERINE FOR THE REGIONAL DIRECTOR**

CRITICAL DATES (if any): **June 15, 2017, In-Person Briefing**

DESCRIPTION/MAIN MESSAGE:

- **THE BRIEFING MEMORANDUM IS TO INFORM THE REGIONAL DIRECTOR OF THE PROGRESS MADE ON THE NORTH AMERICAN WOLVERINE SPECIES STATUS ASSESSMENT REPORT AND THE KEY INFORMATION THAT WILL BE OF INTEREST TO THE WOLVERINE LISTING DECISION.**
- **AN IN-PERSON BRIEFING IS SCHEDULED FOR JUNE 15, 2017 AT 1PM (MST).**
- **BRIEFING TOPICS INCLUDE: UPDATED CURRENT RANGE OF THE SPECIES, TRAPPING DATA IN CANADA, NOAA/CU SNOW PERSISTENCE MODEL, NEW DENNING INFORMATION, POPULATION VIABILITY ANALYSIS AND GENETICS**

SURNAME		
TITLE	NAME	DATE
FIELD OFFICE		
AUTHOR Justin Shoemaker	[signature]	6/12/17
FIELD OFFICE SUPERVISOR/PL		
FIELD OFFICE ADMIN ASSISTANT / FIELD OFFICE ADMINISTRATIVE OFFICER		
REGIONAL OFFICE		
AUTHOR / RO LEAD		
SECRETARY	[initials]	6/12/17
ARD- SCIENCE APPLICATIONS		
ARD – ECOLOGICAL SERVICES		
DARD-ECOLOGICAL SERVICES		
ARD – EXTERNAL AFFAIRS		
ARD – FISHERIES		
ARD – LAW ENFORCEMENT		
ARD – MIGRATORY BIRDS		
ARD – NATL WILDLIFE REFUGE SYSTEM		
ARD- BUDGET/ADMINISTRATION		
CHIEF OF STAFF/RD OFFICE		
SECRETARY / REGIONAL DIRECTOR		
DEPUTY REGIONAL DIRECTOR		
REGIONAL DIRECTOR		
ECOLOGICAL SERVICE REGIONAL OFFICE		
BRANCH CHIEF, CLASSIFICATION AND RECOVERY		
BRANCH CHIEF, LANDSCAPE CONSERVATION AND RESTORATION		
BRANCH CHIEF, DECISION SUPPORT		
DIVISION CHIEF, ECOLOGICAL SERVICES		
DISTRIBUTED (FED EX) (USPS) CIRCLE ONE		

<u>Wolverine Listing Determination Timeline</u>
<u>6/12/17 version</u>

Task	Responsible Parties	Dates	Length of time
Species Status Assessment (SSA) Phase			
FR notice opening comment period on 2013 proposed listing rule	MTFO	Oct 18 2016	done
DIP letters sent out to States and partners	MTFO	Oct	done
Public comment period, input from States, partners, etc.		Oct 18-Nov 17	30 days, done
Conduct science analysis (SSA)	SSA core team	By Sept 15 2017	in process
Draft SSA report	Betty Grizzle (FO Lead Bio)	By Oct 7	in process
SSA core team meeting in Denver	Core team, R6 management and decision support staff	Feb 15-16	2 days, done
SSA report check-in w/ RD	SSA core team, management	June 8	1 hr briefing
Peer review planning and contracting	Justin Shoemaker (ULT lead), Caitlin Snyder (ULT assist)	Aug - Oct	2 months to get contracted peer reviewers in place
SSA report core team review	SSA core team	Oct 7-14	1 week
Edit SSA report based on core team review	Betty Grizzle	Oct 14-Oct 21	1 week
SSA report to peer reviewers and partners*	Justin Shoemaker, Jodi Bush (MTFO Project Leader)	Oct 21-Nov 21	1 month
Edit and finalize SSA report	Betty Grizzle	Nov 21-Dec 19	4 weeks
Listing Decision Analysis Phase			
SSA report to recommendation team	Justin Shoemaker, Jodi Bush	Dec 19	At least 2 weeks prior to recommendation team meeting
Decision meeting	RDs or delegates, ARDs, other management, SSA core team	First or second week of Jan **2018**	2 days
Draft decision summary for the record or certify decision meeting notes	R6 RD or delegate	early Jan	3 days (after recommendation team meeting)
Process for final withdrawal of proposed listing (if decision is to not list) - or revised proposed listing rule (if decision is to list)			
Draft final withdrawal (not-warranted) FR notice or revised proposed listing rule (and if necessary, proposed 10(j), 4(d))	Justin Shoemaker and Betty Grizzle	Jan 15-Feb 12	4 weeks
Core team reviews FR notice,	SSA core team,	Feb 12-Feb 26	2 weeks

*Includes States, Tribes, Federal Agencies

make revisions	Justin Shoemaker		
Regional Office Surnames and concurrence	Marjorie Nelson, Mike Thabault, Matt Hogan, Noreen Walsh, and concurring regional RDs/ARDs or delegates	Feb 26-March 12	2 weeks
SOL surname	DOI SOL	Feb 26-March 12	2 weeks
PPM	PPM	Feb 26-March 12	2 weeks
Revise based on RO/SOL/PPM comments	Justin Shoemaker and Betty Grizzle	March 12-March 21	10 days
HQ review	Sarah Quamme, Bridget Fahey	March 21-	2 weeks (submit 6 weeks prior to FR submittal date)
Asst. Director for ES Surname	Asst. Director for ES	April 4	5 business days
FWS Director Surname	Director of FWS	April 11	5 business days
Fish, Wildlife, and Parks Surname	FWP	April 18	10 business days
Executive Secretary Surname	Executive Secretary's Office	May 2	3 business days
Deliver to FR	HQ	May 7	
Publication of withdrawal or proposed rule	Federal Register	May 14	
Public comment period on revised proposed listing (only if decision is to list)		May 14-June 12	30 days (may need to be 60 days, if so will revise)
Process for final listing Federal Register document			
Comment and response strategy meeting – develop plan to review and address comments received	SSA core team, management	Mid May (TBD)	half day
Review and address public comments on proposed listing	SSA core team, support staffing as needed from R6 RO	June 12-July 16	1 month
Meeting with decision team to discuss public comment and any new info, revisit decision	Marjorie Nelson, Mike Thabault, Matt Hogan, Noreen Walsh, and concurring regional RDs/ARDs or delegates	Early July 2018	half day
Draft final listing FR doc (if necessary 10(j), 4(d))	Justin Shoemaker and Betty Grizzle	by July 16	2 months from proposed listing publication
SSA core team reviews FR notice, make revisions	SSA core team	July 16-July 23	1 week
Regional Office Surnames and concurrence	Marjorie Nelson, Mike Thabault, Matt Hogan, Noreen Walsh, and	July 23-Aug 6	2 weeks

*Includes States, Tribes, Federal Agencies

	concurring regional RDs/ARDs or delegates		
SOL surname	DOI SOL	July 23-Aug 6	2 weeks
PPM	PPM	July 23-Aug 6	2 weeks
Revise based on RO/SOL/PPM comments	Justin Shoemaker and Betty Grizzle	Aug 6-Aug 13	1 week
HQ review	Sarah Quamme, Bridget Fahey	Aug 7	6 weeks prior to FR date (may need to start this review concurrent w/ RO,SOL, PPM revisions)
AES Surname	Assistant Director Ecological Services	Aug 21	5 business days
FWS Director Signature	Director of FWS	Aug 28	5 business days
Fish, Wildlife, and Parks Surname	FWP	Sep 5	10 business days
Executive Secretary Surname	Executive Secretary's Office	Sep 19	3 business days
Deliver to FR	HQ	Sep 24	
Publication of final rule	Federal Register	Sep 28, 2018	Note: We've committed to final rule in FY 18 in the work plan

*Includes States, Tribes, Federal Agencies

ECOLOGICAL SERVICES

#	NAME /TITLE/ OFFICE	LTR*
	Field Office -	F
	Backsen, Sarah	F
	Boroja, Maria	F
	Burgess, Angela	F
	Burgess, Kevin	F
	Gober, Joy	F
	Guinotte, John	F
2	Hansen, Craig	F
	Joersz, Kiana	
	Juliusson, Lara	F
	Kelleher, John/Eileen Lindgren	F
	Konishi, Kathy	F
	Laye, Doug	F
	Lickfett, Todd	F
	Norman, Kate	F
	Orton-Palmer, Amelia	F
	Sattelberg, Mark	F
1	Shoemaker, Justin	F
	Skorupa, Joe	F
	Smith, Kim	F
	Wiechman, Lief	F
3	Nelson, Marjorie/ Chief – Ecological Services	F
	Kales, Matt	F
	Vigil, Trina/Secretary/ ES	F
	Naylon, Jill/Secretary/ES	F
	Alt, Nicole/ Deputy ARD-ES	F / G
4	Thabault, Mike / ARD-ES	F / G
5	Regional Director / Deputy RD	F / G
	External Affairs	F
	Budget Administration	F
	Fisheries	F
	Law Enforcement	F
	Migratory Birds / State Programs	F
	Refuges	F
	Ecological Services	H

* **F** -- surname **G** -- signature **H** -- return to originating office

FROM: Trina Vigil **DATE:** 6/12/17

From:	Jodi Bush
To:	Nelson, Marjorie; nicole_alt@fws.gov
Cc:	Justin Shoemaker/R6/FWS/DOI; Craig Hansen
Subject:	Re: Assignment due NLT July 5 re WAFWA Wolverine Meeting
Date:	Tuesday, June 20, 2017 10:20:01 PM

Yes!

Sent from my iPhone

On Jun 20, 2017, at 2:21 PM, Nelson, Marjorie <marjorie_nelson@fws.gov> wrote:

Justin,
Would you get with the appropriate folks on answering #1.

For number 2: I'll get with Seth if HQ has been moving on the pre-listing 10j - I thought SOL-HQ was writing???? I'm not sure.

It looks like Steve Torbit may do an update on the snow modeling, so we may have to assist with those materials.

thanks,
Marj

Marjorie Nelson
Chief, Division of Ecological Services
Mountain-Prairie Region
U.S. Fish and Wildlife Service
DIFFERENT NUMBER UNTIL 6TH FLOOR FIXED
720-582-3524

---------- Forwarded message ----------
From: **Alt, Nicole** <nicole_alt@fws.gov>
Date: Tue, Jun 20, 2017 at 2:10 PM
Subject: Assignment due NLT July 5 re WAFWA Wolverine Meeting
To: Jodi Bush <jodi_bush@fws.gov>, Marj Nelson <marjorie_nelson@fws.gov>
Cc: Michael Thabault <Michael_Thabault@fws.gov>

Noreen has been asked to attend the WAFWA Wolverine meeting at the summer WAFWA meeting. Specifically, please prepare a few talking points for the RD that cover:

1) an update on the litigation and the status assessment
2) an update on the regulatory certainty through prelising 10j or other mechanisms

Due NLT July 5.

Thanks.

N

Nicole Alt
Deputy ARD Ecological Services
Mountain-Prairie Region
nicole_alt@fws.gov

---------- Forwarded message ----------
From: **Noreen Walsh** <noreen_walsh@fws.gov>
Date: Tue, Jun 20, 2017 at 1:38 PM
Subject: Fwd: WAFWA Wolverine Meeting
To: Michael Thabault <michael_thabault@fws.gov>, Stephen Torbit <Stephen_Torbit@fws.gov>, Nicole Alt <nicole_alt@fws.gov>
Cc: Stephanie Potter <stephanie_potter@fws.gov>, Matt Hogan <matt_hogan@fws.gov>

STeve, were you planning to call in on the snow modeling update topic? Or was a phone connection not going to work?

Mike and Nicole, can you put something brief together for me to update on the other two topics he mentions?

I would need this stuff NLT COB Wednesday July 5.

Thank you,

Noreen

Noreen Walsh
Regional Director
Mountain-Prairie Region
U. S. Fish and Wildlife Service

Begin forwarded message:

> **From:** "McDonald, Ken" <kmcdonald@mt.gov>
> **Date:** June 19, 2017 at 5:47:28 PM CDT
> **To:** "Noreen_Walsh@fws.gov" <Noreen_Walsh@fws.gov>
> **Subject: WAFWA Wolverine Meeting**
>
> Hi Noreen,
>
> Would you or someone from FWS be available to talk to the Wolverine Subcommittee at the upcoming WAFWA wolverine subcommittee meeting on Sunday, July 9? Specifically we are looking for an update on the litigation challenging the not warranted

finding and the status assessment being done. We were also hoping to have someone available to talk about the request from WAFWA directors about some types of regulatory certainty like a 10j rule that could apply pre-listing. Seth Wiley was working with states on that. Finally, we asked Steve Torbit to update the committee on the snow modeling work the FWS was having done. He said he wasn't able to attend – is there someone from your shop that could provide that update?

Many thanks,

Ken McDonald

Wildlife Division Administrator

Montana Fish, Wildlife and Parks

PO Box 200701

Helena, MT 59602

406-444-5645

kmcdonald@mt.gov

From:	A J
To:	Grizzle, Betty
Subject:	Re: Summary paragraph
Date:	Wednesday, June 21, 2017 5:03:41 PM

Also, take out the word "ground" used to describe photographs in the Alaska study area; they were taken from helicopters in most instances.

On Wed, Jun 21, 2017 at 2:45 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:

> Okay, thanks.
>
> On Wed, Jun 21, 2017 at 3:39 PM, A J <222wsheridan@gmail.com> wrote:
>
>> The last sentence is not quite accurate. McKelvey only dealt with the Rockies but the sentence makes it sound like he made predictions even in Alaska. Let me work on it a little.
>>
>> Sent from my iPhone
>>
>> On Jun 21, 2017, at 1:05 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
>>
>> Audrey - Can you take a quick look at this paragraph? I want to make sure that I correctly capture the information presented in your recent publication. Thanks.
>>
>> In an effort to document and compare snow persistence at the wolverine den-site scale, Magoun et al. (2017, entire) evaluated the use of low-altitude aerial photography during late May 2016 in areas within the Rocky Mountains (Idaho and Montana) and northwestern Alaska. Transect segments (established along flight lines) in the Rocky Mountain study areas documented snow on May 31 in all but one segment, with 82 percent classified in low to heavy snow retention categories, and 58 percent considered as moderate to heavy (Magoun et al. 2017, p. 3). In the Alaska study area, ground photographs documented widely scattered patches of snow on May 29, with remnant snowdrifts observed at all four wolverine den sites (Magoun et al. 2017, p. 3). The documentation of the existence of scattered patches of snow persisting into late May in areas located outside where snow cover was predicted to occur on May 29 (MODIS persistent spring snow cover, McKelvey et al. 2011, p. 2,889) suggest that persistent spring cover may not always be detectable at the den-site scale using remote sensing methods (Magoun et al. 2017, p. 4).
>>
>> --
>>
>> Betty J. Grizzle, D.Env.
>> Fish and Wildlife Biologist
>> U.S. Fish and Wildlife Service
>> Carlsbad Fish and Wildlife Office

2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

From: Grizzle, Betty
To: A J
Subject: Re: Summary paragraph
Date: Thursday, June 22, 2017 8:35:36 AM

Thanks Audrey for the clarifications/corrections.

On Wed, Jun 21, 2017 at 4:22 PM, A J <222wsheridan@gmail.com> wrote:

> I suggest citing both these references together in that last sentence so readers can see maps of MODIS May 29 snow cover at both scales
>
> McKelvey et al. 2011, p. 2,889, Fig. 4D
> Magoun et al. 2017, p. 4, Fig. 2b and 2d
>
> On Wed, Jun 21, 2017 at 2:45 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
>
> > Okay, thanks.
> >
> > On Wed, Jun 21, 2017 at 3:39 PM, A J <222wsheridan@gmail.com> wrote:
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> > > The last sentence is not quite accurate. McKelvey only dealt with the Rockies but the sentence makes it sound like he made predictions even in Alaska. Let me work on it a little.
> > >
> > > Sent from my iPhone
> > >
> > > On Jun 21, 2017, at 1:05 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
> > >
> > > Audrey - Can you take a quick look at this paragraph? I want to make sure that I correctly capture the information presented in your recent publication. Thanks.
> > >
> > > In an effort to document and compare snow persistence at the wolverine den-site scale, Magoun et al. (2017, entire) evaluated the use of low-altitude aerial photography during late May 2016 in areas within the Rocky Mountains (Idaho and Montana) and northwestern Alaska. Transect segments (established along flight lines) in the Rocky Mountain study areas documented snow on May 31 in all but one segment, with 82 percent classified in low to heavy snow retention categories, and 58 percent considered as moderate to heavy (Magoun et al. 2017, p. 3). In the Alaska study area, ground photographs documented widely scattered patches of snow on May 29, with remnant snowdrifts observed at all four wolverine den sites (Magoun et al. 2017, p. 3). The documentation of the existence of scattered patches of snow persisting into late May in areas located outside where snow cover was predicted to occur on May 29 (MODIS persistent spring snow cover, McKelvey et al. 2011, p. 2,889) suggest that persistent spring cover may not always be detectable at the den-site scale using remote sensing methods (Magoun et al. 2017, p. 4).

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

--

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Carlsbad, CA 92008
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760-431-5901 fax

From: Mike Sawaya
To: Grizzle, Betty
Subject: Re: Wolverine genetics
Date: Thursday, June 22, 2017 2:44:37 PM

Great, I'll call you then at your office number.

Cheers,
Mike

On Thu, Jun 22, 2017 at 2:30 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:

> Yes, I will be in the office at that time. Thanks again!
>
> On Thu, Jun 22, 2017 at 1:13 PM, Mike Sawaya <sawaya.mike@gmail.com> wrote:
>
>> Betty,
>>
>> I'd be happy to talk with you about wolverine genetics. How about tomorrow morning at 8:30 AM Pacific time? Later in the morning would also work for me.
>>
>> Cheers,
>> Mike
>>
>> On Thu, Jun 22, 2017 at 10:44 AM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
>>
>>> Hello Dr. Sawaya - I am a biologist with the U.S. Fish and Wildlife Service in our Carlsbad, California, field office. I am currently preparing a status review for the North American wolverine for our agency's listing determination. Over the past several months, I have been reviewing many documents/publications and have had conversations with several other researchers to better understand this species and its behavior, physiology, habitat requirements, population genetics, and other characteristics.
>>>
>>> Tony Clevenger suggested I talk with you about wolverine genetic analyses that have been conducted over the past few years (Canada and U.S.). Our agency is currently working to obtain funding to conduct genetic analyses of wolverine samples (hair snags) being collected as part of Multi-state Occupancy Study (WA, ID, MT, WY).
>>>
>>> Do you have time for a phone call? I am in the office today and tomorrow and available next week (except for Friday). My contact information is listed below.
>>> Thanks for your time,
>>> Betty
>>>
>>> --
>>>
>>> Betty J. Grizzle, D.Env.
>>> Fish and Wildlife Biologist
>>> U.S. Fish and Wildlife Service
>>> Carlsbad Fish and Wildlife Office
>>> 2177 Salk Ave, Suite 250
>>> Carlsbad, CA 92008
>>> 760-431-9440, ext. 215
>>> 760-431-5901 fax

--

Michael A. Sawaya, Ph.D.
Carnivore Research Ecologist
Sinopah Wildlife Research Associates

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
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Carlsbad, CA 92008
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760-431-5901 fax

--

Michael A. Sawaya, Ph.D.
Carnivore Research Ecologist
Sinopah Wildlife Research Associates

From:	Bush, Jodi
To:	Nelson, Marjorie; Nicole Alt
Cc:	Justin Shoemaker/R6/FWS/DOI; Craig Hansen; Betty Grizzle
Subject:	Re: Assignment due NLT July 5 re WAFWA Wolverine Meeting
Date:	Friday, June 23, 2017 10:37:23 AM

So I had Betty draw up the following bullet points for WAFWA. Do you think we need more on litigation (?) given Noreen's request - nothing is really happening there. I will include these as part of our larger WAFWA bullets. JB

- In compliance with the April 4, 2016, Montana District Court's order that vacated our previous withdrawal of a proposed rule (published August 13, 2014) to list the contiguous U.S. Distinct Population Segment (DPS) of the North American wolverine, we are conducting a status review for the species and preparing a Species Status Assessment (SSA) Report.

- For the SSA Report, we are reviewing previously considered as well as new information to address the Court's concerns and are using the best available information upon which to base our listing decision. Since the publication of the 2013 proposed rule (February 4, 2013), several new wolverine studies have been published, which have added to our understanding of wolverine biology while also highlighting new insights into identifying key species' needs and their interactions with both abiotic and biotic factors.

- The SSA Report will be submitted to independent peer reviewers and to Federal, State, and other partners to evaluate the scientific accuracy of the report. We expect that submission to occur in late October.

- We will prepare either a revised proposed rule to list or a revised withdrawal of the previous proposed rule in early 2018.

Jodi L. Bush
Office Supervisor
Montana State Ecological Services Office
585 Shepard Way, Suite 1
Helena, MT 59601
(406) 449-5225, ext.205

On Tue, Jun 20, 2017 at 10:19 PM, Jodi Bush <jodi_bush@fws.gov> wrote:

> Yes!
>
> Sent from my iPhone
>
> On Jun 20, 2017, at 2:21 PM, Nelson, Marjorie <marjorie_nelson@fws.gov> wrote:
>
> Justin,

Would you get with the appropriate folks on answering #1.

For number 2: I'll get with Seth if HQ has been moving on the pre-listing 10j - I thought SOL-HQ was writing???? I'm not sure.

It looks like Steve Torbit may do an update on the snow modeling, so we may have to assist with those materials.

thanks,
Marj

Marjorie Nelson
Chief, Division of Ecological Services
Mountain-Prairie Region
U.S. Fish and Wildlife Service
DIFFERENT NUMBER UNTIL 6TH FLOOR FIXED
720-582-3524

---------- Forwarded message ----------
From: **Alt, Nicole** <nicole_alt@fws.gov>
Date: Tue, Jun 20, 2017 at 2:10 PM
Subject: Assignment due NLT July 5 re WAFWA Wolverine Meeting
To: Jodi Bush <jodi_bush@fws.gov>, Marj Nelson <marjorie_nelson@fws.gov>
Cc: Michael Thabault <Michael_Thabault@fws.gov>

Noreen has been asked to attend the WAFWA Wolverine meeting at the summer WAFWA meeting. Specifically, please prepare a few talking points for the RD that cover:

1) an update on the litigation and the status assessment
2) an update on the regulatory certainty through prelising 10j or other mechanisms

Due NLT July 5.

Thanks.

N

Nicole Alt
Deputy ARD Ecological Services
Mountain-Prairie Region
nicole_alt@fws.gov

---------- Forwarded message ----------
From: **Noreen Walsh** <noreen_walsh@fws.gov>
Date: Tue, Jun 20, 2017 at 1:38 PM
Subject: Fwd: WAFWA Wolverine Meeting
To: Michael Thabault <michael_thabault@fws.gov>, Stephen Torbit <Stephen_Torbit@fws.gov>, Nicole Alt <nicole_alt@fws.gov>

Cc: Stephanie Potter <stephanie_potter@fws.gov>, Matt Hogan <matt_hogan@fws.gov>

STeve, were you planning to call in on the snow modeling update topic? Or was a phone connection not going to work?

Mike and Nicole, can you put something brief together for me to update on the other two topics he mentions?

I would need this stuff NLT COB Wednesday July 5.

Thank you,

Noreen

Noreen Walsh
Regional Director
Mountain-Prairie Region
U. S. Fish and Wildlife Service

Begin forwarded message:

From: "McDonald, Ken" <kmcdonald@mt.gov>
Date: June 19, 2017 at 5:47:28 PM CDT
To: "Noreen_Walsh@fws.gov" <Noreen_Walsh@fws.gov>
Subject: WAFWA Wolverine Meeting

Hi Noreen,

Would you or someone from FWS be available to talk to the Wolverine Subcommittee at the upcoming WAFWA wolverine subcommittee meeting on Sunday, July 9? Specifically we are looking for an update on the litigation challenging the not warranted finding and the status assessment being done. We were also hoping to have someone available to talk about the request from WAFWA directors about some types of regulatory certainty like a 10j rule that could apply pre-listing. Seth Wiley was working with states on that. Finally, we asked Steve Torbit to update the committee on the snow modeling work the FWS was having done. He said he wasn't able to attend – is there someone from your shop that could provide that update?

Many thanks,

Ken McDonald

Wildlife Division Administrator

Montana Fish, Wildlife and Parks

PO Box 200701

Helena, MT 59602

406-444-5645

kmcdonald@mt.gov

From: Google Calendar on behalf of andrea.ray@noaa.gov
To: john_guinotte@fws.gov; stephen_torbit@fws.gov; imtiaz.rangwala@noaa.gov; joseph.barsugli@noaa.gov; beli1098@colorado.edu
Subject: Wolverine meeting in Boulder please RSVP
Attachments: invite.ics

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more details » <https://www.google.com/calendar/event?
action=VIEW&eid=am02NzBiZ2JsZGNmcXY2MTlqM2ExOTRiMG8gam9obl9ndWlub3R0ZUBmd3MuZ292&tok=MTkjYW5kcmVhLnJheUBub2FhLmdvdmM0NTYyODcwNzI1MjAzYTRmZGE1NDYwOWMwMTQwZGViMjM5OTg2OWQ&ctz=America/Denver&hl=en>

Wolverine meeting in Boulder please RSVP

NOTE -- I am still looking for an alternate time on Thursday June 28th
When
Fri Jul 7, 2017 9am – 10:30am Mountain Time
Where
Boulder, DSRC - 1D708 (map <https://maps.google.com/maps?q=Boulder,+DSRC+-+1D708&hl=en>)
Calendar
john_guinotte@fws.gov
Who
• andrea.ray@noaa.gov
- organizer
• stephen_torbit@fws.gov
• john_guinotte@fws.gov
• imtiaz.rangwala@noaa.gov
• joseph.barsugli@noaa.gov
• beli1098@colorado.edu

Going?
Yes <https://www.google.com/calendar/event?
action=RESPOND&eid=am02NzBiZ2JsZGNmcXY2MTlqM2ExOTRiMG8gam9obl9ndWlub3R0ZUBmd3MuZ292&rst=1&tok=MTkjYW5kcmVhLnJheUBub2FhLmdvdmM0NTYyODcwNzI1MjAzYTRmZGE1NDYwOWMwMTQwZGViMjM5OTg2OWQ&ctz=America/Denver&hl=en>
-
Maybe <https://www.google.com/calendar/event?
action=RESPOND&eid=am02NzBiZ2JsZGNmcXY2MTlqM2ExOTRiMG8gam9obl9ndWlub3R0ZUBmd3MuZ292&rst=3&tok=MTkjYW5kcmVhLnJheUBub2FhLmdvdmM0NTYyODcwNzI1MjAzYTRmZGE1NDYwOWMwMTQwZGViMjM5OTg2OWQ&ctz=America/Denver&hl=en>
-
No <https://www.google.com/calendar/event?
action=RESPOND&eid=am02NzBiZ2JsZGNmcXY2MTlqM2ExOTRiMG8gam9obl9ndWlub3R0ZUBmd3MuZ292&rst=2&tok=MTkjYW5kcmVhLnJheUBub2FhLmdvdmM0NTYyODcwNzI1MjAzYTRmZGE1NDYwOWMwMTQwZGViMjM5OTg2OWQ&ctz=America/Denver&hl=en>
more options » <https://www.google.com/calendar/event?
action=VIEW&eid=am02NzBiZ2JsZGNmcXY2MTlqM2ExOTRiMG8gam9obl9ndWlub3R0ZUBmd3MuZ292&tok=MTkjYW5kcmVhLnJheUBub2FhLmdvdmM0NTYyODcwNzI1MjAzYTRmZGE1NDYwOWMwMTQwZGViMjM5OTg2OWQ&ctz=America/Denver&hl=en>

achment 20170623 163448_EM_Wolverine meeting in Boulder please RSVP.ics (1989 Bytes) cannot be converted to PDF forr

From:	Ben Livneh
To:	Guinotte, John
Cc:	Andrea Ray - NOAA Federal; Joseph Barsugli - NOAA Affiliate; Steve Torbit
Subject:	Re: Wolverine meeting in Boulder?
Date:	Monday, June 26, 2017 8:19:15 AM

Hi folks,
I'll be up at Niwot Ridge on Thursday, so perhaps someone can fill me in on what gets discussed. There was a mix-up earlier about 28 June vs 29 June, pardon the confusion.

Ben

On Mon, Jun 26, 2017 at 7:56 AM, Guinotte, John <john_guinotte@fws.gov> wrote:

> Hi Andrea and Ben,
> I think Steve would agree sooner is better. We are both free on Thurs June 29 at 9 am. I will join remotely on phone/go to meeting.
> Thanks for setting this up.
> Best, John
>
> John Guinotte
> Spatial Ecologist
> Ecological Services
> U.S. Fish and Wildlife Service
> Mountain Prairie Region 6
> 134 Union Blvd., Lakewood, CO 80228
> 303-236-4264
> john_guinotte@fws.gov
>
> On Fri, Jun 23, 2017 at 4:28 PM, Andrea Ray - NOAA Federal <andrea.ray@noaa.gov> wrote:
>
>> Thanks, Ben -- lets try for 9a. Please pencil that in for both days while I wait to hear from others. I'll send a calendar invitation for both days at 9 and then I'll cancel one. Steve is out of the office today, so we won't hear from him until monday
>>
>> Thanks, Andrea
>>
>> On Fri, Jun 23, 2017 at 3:54 PM, Ben Livneh <Ben.Livneh@colorado.edu> wrote:
>>
>>> Hi folks,
>>> I'd prefer 9:00 am on either day, as at least the first one (28th) I have a 10:30 meeting.
>>> Ben
>>>
>>> On Fri, Jun 23, 2017 at 12:48 PM, Andrea Ray - NOAA Federal <andrea.ray@noaa.gov> wrote:
>>>
>>>> Steve, et al, (fyi for Imtiaz),
>>>>
>>>> Thursday 28 June and Friday 7 July work for us for wolverine meetings up here in boulder. I propose 10 am, let me know if that still works, so we can get this on the calendar. If 10 on either day doesn't work, let me know what does. I understand that John may call in, we'll plan to have a go to meeting.
>>>>
>>>> thanks, and have a good weekend, all. Andrea

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--
Andrea J. Ray, Ph.D.
NOAA Earth System Research Lab, Mailcode R/PSD1
325 Broadway, Boulder, CO 80305-3328
(tel) 303-497-6434
(fax) 303-497-6449
andrea.ray@noaa.gov
www.researchgate.net/profile/Andrea_Ray2

--
Ben Livneh, Ph.D
Assistant Professor, Department of Civil, Environmental, and Architectural Engineering
&
Fellow, Cooperative Institute for Research in Environmental Sciences (CIRES)
Campus Box 216 UCB, Ekeley S250C, University of Colorado, Boulder 80309, USA
Phone: 303-735-0288 | http://www.colorado.edu/lab/livneh/

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Campus Box 216 UCB, Ekeley S250C, University of Colorado, Boulder 80309, USA
Phone: 303-735-0288 | http://www.colorado.edu/lab/livneh/

From:	Guinotte, John
To:	Andrea Ray - NOAA Federal
Cc:	Joseph Barsugli - NOAA Affiliate; Ben Livneh; Steve Torbit
Subject:	Re: Wolverine meeting in Boulder?
Date:	Monday, June 26, 2017 8:28:01 AM

Sounds good Andrea. I can do July 7th and Steve's calendar says he is free that am.
Thanks John

John Guinotte
Spatial Ecologist
Ecological Services
U.S. Fish and Wildlife Service
Mountain Prairie Region 6
134 Union Blvd., Lakewood, CO 80228
303-236-4264
john_guinotte@fws.gov

On Mon, Jun 26, 2017 at 8:24 AM, Andrea Ray - NOAA Federal <andrea.ray@noaa.gov> wrote:

> Unfortunately, Ben is in the field all day that day, and he's not available on Friday. So the 7th is the earliest day of the ones Steve gave me (thurs-Fri of those weeks)
>
> On Mon, Jun 26, 2017 at 7:56 AM, Guinotte, John <john_guinotte@fws.gov> wrote:
>
>> Hi Andrea and Ben,
>> I think Steve would agree sooner is better. We are both free on Thurs June 29 at 9 am. I will join remotely on phone/go to meeting.
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>> John Guinotte
>> Spatial Ecologist
>> Ecological Services
>> U.S. Fish and Wildlife Service
>> Mountain Prairie Region 6
>> 134 Union Blvd., Lakewood, CO 80228
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>> john_guinotte@fws.gov
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>>
>>> Thanks, Ben -- lets try for 9a. Please pencil that in for both days while I wait to hear from others. I'll send a calendar invitation for both days at 9 and then I'll cancel one. Steve is out of the office today, so we won't hear from him until monday
>>>
>>> Thanks, Andrea
>>>
>>> On Fri, Jun 23, 2017 at 3:54 PM, Ben Livneh <Ben.Livneh@colorado.edu> wrote:
>>>
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Ben

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Thursday 28 June and Friday 7 July work for us for wolverine meetings up here in boulder. I propose 10 am, let me know if that still works, so we can get this on the calendar. If 10 on either day doesn't work, let me know what does. I understand that John may call in, we'll plan to have a go to meeting.

thanks, and have a good weekend, all. Andrea

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(fax) 303-497-6449
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&
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(tel) 303-497-6434
(fax) 303-497-6449
andrea.ray@noaa.gov
www.researchgate.net/profile/Andrea_Ray2

From: Grizzle, Betty
To: A J
Subject: Re: life in a wolverine den
Date: Monday, June 26, 2017 8:32:00 AM

Thanks so much for sharing this. Really nice photos with additional insight into their denning behavior. Still so much to learn about this amazing animals! Will definitely fit this purchase into my budget. Congratulations to you and Dale for getting this published.
Betty

On Sun, Jun 25, 2017 at 4:41 PM, A J <222wsheridan@gmail.com> wrote:

> Hi Betty
> Here is an announcement of a new book that a friend and I self-published recently. These photos were taken at a captive facility after years of learning how to breed wolverines and hand-rearing a female that would let Dale come into the den with her and her kits. The book provides lots of photos showing the development of kits from birth to thirteen weeks of age, giving researchers an idea of each stage of development through the denning season. It's an expensive book but priceless!
>
> Hey wolverine enthusiasts!
> The long-awaited book on what life is like inside a wolverine dens is completed and available from Blurb.com; here's the direct link:
>
> http://www.blurb.com/b/7989395-deep-snow-and-four-below
>
> Don't cringe at the price. I realize for the price of just two of these books, you could buy a new iphone or a Reconyx trail camera, but wait until you see it. Worth every penny. It took Dale years to get this opportunity to photograph inside a wolverine den every day for 13 weeks to document the development and behavior of wolverine kits and their mother. The photos are priceless and not to be duplicated by anyone else for a long time, I'm sure. Self-publishing each book individually as the order is made is an expensive way to produce a book, but I suspect we will have a limited audience and so cannot afford a bulk order necessary to bring down the price appreciably. Afterall, how many wolverine enthusiasts can there be out there??!!! Hopefully, any researcher interested in learning more about wolverines will jump at the chance to own this book, but if not, we are just so happy to finally get it finished and documented for posterity. Please pass this notice on to anyone you think might be interested.
> Thanks much,
> Audrey

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

From: Google Calendar on behalf of andrea.ray@noaa.gov
To: john_guinotte@fws.gov; imtiaz.rangwala@noaa.gov; joseph.barsugli@noaa.gov; beli1098@colorado.edu; stephen_torbit@fws.gov; coury.ditch@noaa.gov
Subject: Wolverine meeting in Boulder please RSVP
Attachments: invite.ics

This event has been changed.

more details » <https://www.google.com/calendar/event?
action=VIEW&eid=am02NzBiZ2JsZGNmcXY2MTlqM2ExOTRiMG8gam9obl9ndWlub3R0ZUBmd3MuZ292&tok=MTkjYW5kcmVhLnJheUBub2FhLmdvdmM0NTYyODcwNzI1MjAzYTRmZGE1NDYwOWMwMTQwZGViMjM5OTg2OWQ&ctz=America/Denver&hl=en>

Wolverine meeting in Boulder please RSVP

if needed: https://global.gotomeeting.com/join/925942125 <https://www.google.com/url?q=https%3A%2F%2Fglobal.gotomeeting.com%2Fjoin%2F925942125&sa=D&ust=1498516120502000&usg=AFQjCNFy3ItJll5SAIeUjFRpTw5gIwFCaw>

You can also dial in using your phone.
United States: +1 (408) 650-3123

Access Code: 925-942-125

When
Fri Jul 7, 2017 9am – 10:30am Mountain Time
Where
Changed: in person in Boulder, DSRC - 1D708 (the usual place) (map <https://maps.google.com/maps?q=in+person+in+Boulder,+DSRC+-+1D708+%28the+usual+place%29&hl=en>)
Calendar
john_guinotte@fws.gov
Who
• andrea.ray@noaa.gov
- organizer
• imtiaz.rangwala@noaa.gov
• john_guinotte@fws.gov
• joseph.barsugli@noaa.gov
• beli1098@colorado.edu
• stephen_torbit@fws.gov
• coury.ditch@noaa.gov

Going?
Yes <https://www.google.com/calendar/event?
action=RESPOND&eid=am02NzBiZ2JsZGNmcXY2MTlqM2ExOTRiMG8gam9obl9ndWlub3R0ZUBmd3MuZ292&rst=1&tok=MTkjYW5kcmVhLnJheUBub2FhLmdvdmM0NTYyODcwNzI1MjAzYTRmZGE1NDYwOWMwMTQwZGViMjM5OTg2OWQ&ctz=America/Denver&hl=en>
-
Maybe <https://www.google.com/calendar/event?
action=RESPOND&eid=am02NzBiZ2JsZGNmcXY2MTlqM2ExOTRiMG8gam9obl9ndWlub3R0ZUBmd3MuZ292&rst=3&tok=MTkjYW5kcmVhLnJheUBub2FhLmdvdmM0NTYyODcwNzI1MjAzYTRmZGE1NDYwOWMwMTQwZGViMjM5OTg2OWQ&ctz=America/Denver&hl=en>
-
No <https://www.google.com/calendar/event?
action=RESPOND&eid=am02NzBiZ2JsZGNmcXY2MTlqM2ExOTRiMG8gam9obl9ndWlub3R0ZUBmd3MuZ292&rst=2&tok=MTkjYW5kcmVhLnJheUBub2FhLmdvdmM0NTYyODcwNzI1MjAzYTRmZGE1NDYwOWMwMTQwZGViMjM5OTg2OWQ&ctz=America/Denver&hl=en>
more options » <https://www.google.com/calendar/event?
action=VIEW&eid=am02NzBiZ2JsZGNmcXY2MTlqM2ExOTRiMG8gam9obl9ndWlub3R0ZUBmd3MuZ292&tok=MTkjYW5kcmVhLnJheUBub2FhLmdvdmM0NTYyODcwNzI1MjAzYTRmZGE1NDYwOWMwMTQwZGViMjM5OTg2OWQ&ctz=America/Denver&hl=en>

achment 20170626 142900_EM_Wolverine meeting in Boulder please RSVP.ics (2241 Bytes) cannot be converted to PDF forn

From:	Shoemaker, Justin
To:	Brent Esmoil
Subject:	Re: Wolverine BP?
Date:	Thursday, June 29, 2017 9:55:02 AM
Attachments:	Briefing paper wolverine reinstatement 8.29.16.docx

Brent,

We haven't updated a BP since the announcement of the proposed rule reinstatement. Here's the BP from last fall.

Not sure this fits the bill. We do have a briefing memo to the RD that we used just a few weeks ago, but that is specific to new info in the SSA we wanted her to be aware of.

Justin Shoemaker
Classification and Recovery Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

On Thu, Jun 29, 2017 at 10:39 AM, Brent Esmoil <brent_esmoil@fws.gov> wrote:

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> Brent
>
>
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>
> Deputy Field Supervisor
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> U.S. Fish and Wildlife Service
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> Montana ES Field Office
>
> 585 Shephard Way, Suite 1
>
> Helena, Montana 59601
>
> 406-449-5225, ext. 215
>
> www.fws.gov/montanafieldoffice
>

August 29, 2016

INFORMATION MEMORANDUM FOR THE DIRECTOR

FROM: Gary Frazer, Assistant Director, Endangered Species

CC: Regional Director, Region 6

SUBJECT: Reopening of the comment period on wolverine proposed rule and announcement of new status review

I. INTRODUCTION

As a result of a court decision, we are publishing a notice to reopen the comment period on our February 4, 2013 proposed rule to list a distinct population segment (DPS) of wolverine as threatened under the Endangered Species Act (Act). We will also announce the initiation of a new status review of the wolverine DPS, to determine whether it meets the definition of an endangered or threatened species under the Act.

II. BACKGROUND

On February 4, 2013, we published a proposed rule to list the DPS of wolverine occurring in the contiguous United States as threatened, under Act, with a proposed 4(d) rule that outlined the prohibitions necessary and advisable for the conservation of the wolverine. We also published proposed 10(j) rule to establish a NEP area for the North American wolverine in the Southern Rocky Mountains of Colorado, northern New Mexico, and southern Wyoming. On August 13, 2014, we withdrew the proposed rule to list the DPS of the North American wolverine as a threatened species, based on our conclusion that the factors affecting the DPS as identified in the proposed rule were not as significant as believed at the time of the proposed rule's publication.

In October 2014, three complaints were filed in the District Court for the District of Montana by several organizations challenging the withdrawal of the proposal to list the wolverine DPS. On April 4, 2016, the District Court vacated our withdrawal of our proposed rule, which effectively returns the process to the stage of the proposed listing rule we published in 2013.

This notice clarifies to the public the current status of the species, and reopens the public comment period on the proposed rule to list the DPS. It also announces to the public that we are initiating an entirely new status review of the North American wolverine, to determine whether this DPS meets the definition of an endangered or threatened species under the Act, or whether the species is not warranted for listing. We also request new information regarding the North American wolverine to inform this status review.

III. POSITION OF INTERESTED PARTIES:

The information contained in this memorandum is for informational and outreach purposes only and has not been used as the basis for any potential Agency decision.

Although no parties have taken public positions on this specific action, most parties should already be aware of the outcome of the court case regarding the withdrawal of the proposed listing rule. The states within the wolverine's range were supportive of the original withdrawal. The U.S. Forest Service and National Park Service did not take a position on the original listing determination. In general, this notice will provide clarity to Federal agencies regarding the species' status for Section 7 purposes. The plaintiffs in the litigation over the withdrawal are expected to be supportive of the species' proposed status being back in place, but concerned with the timeline for a final determination.

IV. POTENTIAL ISSUES:

We are careful to indicate in our notice that the current "proposed species" status of the wolverine is the effective result of a court decision, and not necessarily an indication of our current understanding of the biological status of the species. Our new status review will be based on the best available scientific information, and could result in the species being warranted for listing as endangered, threatened, or not warranted for listing at all.

Discussions regarding the timeline for a new listing determination are ongoing with plaintiffs.

From:	Shoemaker, Justin
To:	Brent Esmoil
Subject:	Re: Wolverine BP?
Date:	Thursday, June 29, 2017 10:15:37 AM
Attachments:	Briefing Memo for RD_Wolverine SSA update_06142017.docx

Here's that memo we did for Noreen recently. I wouldn't include the highlighted in a BP for this assignment, but the other language may be useful.

Justin Shoemaker
Classification and Recovery Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

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>> 585 Shephard Way, Suite 1
>>
>> Helena, Montana 59601

406-449-5225, ext. 215

www.fws.gov/montanafieldoffice

BRIEFING MEMORANDUM FOR THE REGIONAL DIRECTOR

DATE: June 14, 2017

FROM: Michael Thabault, Assistant Regional Director, Ecological Services

SUBJECT: Wolverine Species Status Assessment Update

To inform the Regional Director of the progress made on the North American wolverine (wolverine) Species Status Assessment (SSA) Report and the key information that will be of interest to the eventual wolverine listing decision. A Regional Director briefing is scheduled for June 15.

BACKGROUND

In compliance with the April 4, 2016, Montana District Court's (Court) order that vacated our previous withdrawal of a proposed rule to list the contiguous U.S. Distinct Population Segment (DPS) of the wolverine (79 FR 47522; August 13, 2014), we will prepare either a revised proposed rule to list or a revised withdrawal of the previous proposed rule (78 FR 7864; February 4, 2013). On October 18, 2016 (81 FR 71670), we published a Federal Register notice that announced the vacature of the withdrawal rule, the proposed status reinstation, and the reopening of the public comment period on the February 4, 2013, proposed rule to list the wolverine as a threatened species.

DISCUSSION

Court Order – Highlighted in the Court's order were the U. S. Fish and Wildlife Service's determinations regarding: (a) the threat posed to the wolverine by the effects of climate change at the reproductive denning scale, (b) the threat posed to the wolverine by small population size and lack of genetic diversity, and (c) application of the Significant Portion of its Range (SPR) Policy to the wolverine. In our SSA Report, we are reviewing previously considered and new information to address the Court's concerns and we are using the best available information upon which to base our listing decision.

Range of the Species – Based on both previously considered and new information, we have revised the wolverine range across the contiguous United States. The revised range is smaller than what was considered in previous rules.

Trapping Data – We have additional trapping data that were not available to us in 2014, which we are using to inform the species' range and trapping impacts in Canada (British Columbia and Alberta).

National Oceanic and Atmospheric Administration and University of Colorado Snow Persistence Model – High resolution snow pack models have been developed for Glacier and Rocky Mountain National Parks. These areas bracket the DPS range for the wolverine in the contiguous United States. Most model scenarios indicate significant future snow persistence through April and May for 1) elevations currently used for denning in Glacier National Park and 2) the inferred elevations where wolverines would be expected to den in Rocky Mountain National Park.

New denning information – We have received new information on wolverine research that was not available to us in 2014, including several peer-reviewed publications. This new information provides additional insights into the timing and location of wolverine den sites such as documentation of natal den sites in locations outside of areas previously predicted by Copeland et al.'s (2010) snow model in North America and in Scandinavia.

Population Viability Analysis (PVA) – We are coordinating with the United States Geological Survey to develop a PVA to inform minimum viable population size and to develop future scenarios that model the potential effects of demographic and habitat parameters on the wolverine's population in the contiguous United States.

Genetics – Regarding our 2014 withdrawal, the Court stated that we failed to articulate how our statements regarding the following did not constitute adverse effects to wolverine:

- Apparent loss of connectivity between Rocky Mountains and Canada prevented influx of genetic material needed to maintain or increase the genetic diversity in the contiguous United States.
- Effective population size is too low to support the subpopulations in the contiguous United States.
- Genetic drift has already occurred in subpopulations in the contiguous United States as compared to Canada, and a continued loss of genetic diversity may lead to inbreeding depression and inability of wolverines to persist in the contiguous United States.

To address these concerns, we need to reevaluate these genetic issues. As such, we need to determine whether there is a threat for inbreeding depression based on small population size. In addition, knowledge gained through a more thorough and complete analysis of the genetic structure of wolverine populations throughout North America would better inform our listing determination.

NEXT STEPS

We plan to present the final SSA Report, with peer and partner review incorporated, to the RD and decision team by December 2017.

ATTACHMENTS

See attached for a schedule outlining steps and timelines for preparation of the SSA Report and listing decision documents.

From:	Brent Esmoil
To:	Justin Shoemaker
Subject:	RE: Wolverine BP?
Date:	Thursday, June 29, 2017 10:18:21 AM

Thanks Justin! I'll take a look once I'm off my conference call.

Brent Esmoil
Deputy Field Supervisor
U.S. Fish and Wildlife Service
Montana ES Field Office
585 Shephard Way, Suite 1
Helena, Montana 59601
406-449-5225, ext. 215
www.fws.gov/montanafieldoffice

From: Shoemaker, Justin [mailto:justin_shoemaker@fws.gov]
Sent: Thursday, June 29, 2017 10:16 AM
To: Brent Esmoil
Subject: Re: Wolverine BP?

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Justin Shoemaker
Classification and Recovery Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

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Brent

Brent Esmoil
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406-449-5225, ext. 215
www.fws.gov/montanafieldoffice

From: Brent Esmoil
To: Justin Shoemaker; Betty Grizzle
Subject: RE: Draft Wolverine BP for review
Date: Thursday, June 29, 2017 1:51:39 PM

Thanks to both of you for the speedy review. Now I'll see if I can get it to one page.

Brent Esmoil
Deputy Field Supervisor
U.S. Fish and Wildlife Service
Montana ES Field Office
585 Shephard Way, Suite 1
Helena, Montana 59601
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www.fws.gov/montanafieldoffice

From: Shoemaker, Justin [mailto:justin_shoemaker@fws.gov]
Sent: Thursday, June 29, 2017 1:42 PM
To: Grizzle, Betty
Cc: Brent Esmoil
Subject: Re: Draft Wolverine BP for review

A couple more suggestions added to Betty's version.

Justin Shoemaker
Classification and Recovery Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

On Thu, Jun 29, 2017 at 2:35 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
Just a few suggestions. See attached.

On Thu, Jun 29, 2017 at 12:30 PM, Brent Esmoil <brent_esmoil@fws.gov> wrote:
Betty and Justin:

Could you take a quick look at the attached draft and let me know your thoughts regarding its readiness for submission? Feel free to edit at will. Thanks!

Brent Esmoil
Deputy Field Supervisor
U.S. Fish and Wildlife Service
Montana ES Field Office
585 Shephard Way, Suite 1
Helena, Montana 59601
406-449-5225, ext. 215
www.fws.gov/montanafieldoffice

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Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

From:	A J
To:	Grizzle, Betty
Subject:	Re: Wolverine home range questions
Date:	Thursday, June 29, 2017 12:03:54 PM

Betty
Are you sure about the value for Dawson? I will have to look that up again. Seems it was larger. I did the radiotracking.

On Thu, Jun 29, 2017 at 9:46 AM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:

> Thanks Audrey.
> After I sent the email, I did find from Inman et al (2012, J Mammalogy): minimum of 100–150 km2 (39– 58 mi2) (i.e., during year raising young) and from Dawson et al. (2010) 262 km2 (101 mi2) for a lactating female.
>
> On Thu, Jun 29, 2017 at 10:10 AM, A J <222wsheridan@gmail.com> wrote:
>
>> Hi Betty
>> The calculation from my thesis is one of the smallest home range for lactating females. From all studies I have seen, Malin's value as you calculated is probably closer to an "average." The highest I have seen is about 500 km2 (Aubry's work in the Cascades of Washington) and about 400 km2 (in Ontario). I think 3 things affect size: food abundance, food distribution, and density of resident females (affected by mortality rates). I believe a paper by Jens Persson has a table with all known home ranges for lactating females at that time (2013????). I'll try to find it for you. Also, as kits mature over summer, it appears a female could expand her movements into areas where the resident there has disappeared, and that affects researchers' calculations of home range of reproductive females.
>>
>> Sent from my iPhone
>>
>> > On Jun 29, 2017, at 8:52 AM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
>> >
>> > Hi Audrey - Can you help me with a few questions? What is the average "home range" size of a lactating female wolverine? In your dissertation, you calculated an average of 70 square kilometers (pp. 36-37). Would this be the same value for a female wolverine (raising young) during the entire time when she is using the natal den?
>> >
>> > In Malin's paper V, she mentions a mean distance from natal den site to first own den or centre point of home ranges (for established females) of 17 km (plus/minus 6.4 km). Could I also use Malin's value (assuming radius is half of 17 km) to calculate a comparable home range (assuming circular area, A=3.14*(8.5 km)^2) = 227 square kilometers)?
>> >
>> > Thanks for your time,
>> > Betty
>> > --
>> >
>> > Betty J. Grizzle, D.Env.
>> > Fish and Wildlife Biologist
>> > U.S. Fish and Wildlife Service
>> > Carlsbad Fish and Wildlife Office

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From: Grizzle, Betty
To: A J
Subject: Re: Dawson
Date: Thursday, June 29, 2017 12:17:47 PM

Yes, correct. I do my best to note all of the various methodologies when presenting and comparing values as I know they can give varying results.

On Thu, Jun 29, 2017 at 11:10 AM, A J <222wsheridan@gmail.com> wrote:

> OK, I see, you are using the 95% MCP

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
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760-431-9440, ext. 215
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From: A J
To: Grizzle, Betty
Date: Thursday, June 29, 2017 12:19:27 PM
Attachments: eur_j_wildl_res_2010_perssonspace_use_and_territoriality_of_wolverines_gulo_gulo_in_northern_scandinavia5649-571.pdf

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This may be the paper I was thinking of---see Table 1.

Eur J Wildl Res (2010) 56:49–57
DOI 10.1007/s10344-009-0290-3

ORIGINAL PAPER

Space use and territoriality of wolverines (*Gulo gulo*) in northern Scandinavia

Jens Persson · Per Wedholm · Peter Segerström

Received: 7 October 2008 / Revised: 25 May 2009 / Accepted: 28 May 2009 / Published online: 18 June 2009

Abstract Space use and territoriality influence population structure and dynamics and is therefore an important aspect in understanding the ecology of animals. We investigated spatial and temporal space use of wolverines (*Gulo gulo*) in northern Scandinavia. We estimated home ranges of 24 radio-marked individuals (17 females and seven males). Male home ranges (mean 669 km^2; SE=211) were significantly larger than female home ranges (mean 170 km^2; Wilcoxon–Mann–Whitney; P=0.001) and encompassed or included parts of up to five different females. Home range sizes of reproducing (170 km^2; SE=51) and barren (171 km^2; SE=63) adult females did not differ. Wolverines in Scandinavia exhibit intrasexual territoriality, with male home ranges totally exclusive and female home ranges either exclusive or with little home range overlap. Overlap between wolverine territories is most likely explained by intrasexual tolerance and kinship.

Keywords Carnivore · Home range · Mustelid · Overlap · Social organisation

Introduction

The spacing pattern of animals is the result of the tactics used by individual animals in their attempts to survive and maximise reproductive success (Sandell 1989). Animals compete for different resources, such as food, shelter, and mates (Maher and Lott 1995). One way to compete is to exclude potential competitors from the area containing the resources (i.e., being territorial; Noble 1939; Schoener 1968; Brown and Orians 1970). A home range is defined as the area covered by the animals in their normal day-to-day activities and territory as that area which is defended against conspecifics (Burt 1943). Variation in home range size may lead to unequal division of resources among competitors, resulting in differential rates of growth, mortality, and reproduction (Adams 2001). Territorial behaviour can, thus, have strong effects on population structure and dynamics and is an important aspect in understanding animal ecology (Adams 2001).

The wolverine (*Gulo gulo*) is a solitary generalist predator and scavenger, occupying tundra, taiga, and forest zones of North America and Eurasia (Banci 1994). Because wolverine populations generally occur at low densities and occupy remote and rugged habitats, few studies of free-ranging wolverines have been conducted. Only in recent years has fundamental knowledge on wolverine demography been gained (Persson et al. 2003, 2006, 2009; Krebs et al. 2004; Persson 2005). Published information about wolverine spatial dynamics originates from a few telemetry studies (Hornocker and Hash 1981; Whitman et al. 1986; Landa et al. 1998; Vangen et al. 2001).

Like most mustelids (Powell 1979), wolverines exhibit intrasexual territoriality and varying degrees of intrasexual overlap (Banci 1994). Spatial organisation in solitary carnivores is determined by different resources for each sex; female home ranges would be determined by food resources while male home ranges would be determined by the number and distribution of females (Sandell 1989). This corresponds with the polygamous mating system of wolverines, which predicts that male home ranges should be larger than females (Hedmark et al. 2007).

Communicated by P. Krausman

J. Persson (✉) · P. Segerström
Grimsö Wildlife Research Station, Department of Ecology,
Swedish University of Agricultural Sciences,
730 91 Riddarhyttan, Sweden
e-mail: jens.persson@ekol.slu.se

P. Wedholm
Örebro County Administrative Board,
Stortorget 22,
701 86 Örebro, Sweden

Globally, the wolverine is classified as vulnerable (Mustelid Specialist Group 1996). Conservation concerns include primarily habitat fragmentation, overexploitation, and depredation conflicts with sheep and reindeer husbandry (Landa et al. 2000; Slough 2007; Zhang et al. 2007). The Scandinavian wolverine population's distribution and size declined markedly during the 1900s (Flagstad et al. 2004). Currently, ≥1/2 of the Scandinavian wolverine population, estimated at about 780 individuals, reside in Sweden (Persson 2007) where it is classified as endangered (Gärdenfors 2000). The distribution of wolverines in Sweden largely overlaps with that of semi-domestic reindeer (*Rangifer tarandus*), which is the predominant prey of wolverines (Persson 2005). Locally, reindeer husbandry suffers from heavy predation by wolverines and other predators (Swenson and Andrén 2005). As a result, poaching and lethal control forms a substantial part of wolverine population dynamics in northern Scandinavia (Persson et al. 2009).

In light of current conflicts and lack of knowledge, more information is needed to understand spatial ecology of wolverines and to enable sound management of the species. Therefore, in this study, we examine space use and social organisation in wolverines. In particular, we assess age and sex specific home range size and territoriality.

Materials and methods

Study area

This study was conducted in and around Sarek National Park in northern Sweden above the Arctic Circle (Kvikkjokk: 67°00′N, 17°40′E). The climate is continental, and the ground is usually snow-covered from November to late May. The area is characterised by deep valleys, glaciers, and high alpine plateaus with peaks ≤2,000 m above sea level. The valleys are dominated by mountain birch (*Betula pubescens*), Scots pine (*Pinus sylvestris*), and Norway spruce (*Picea abies*), while mountain birch forms the tree line at 600–700 m above sea level (Grundsten 1997). Semi-domestic reindeer are managed exclusively and extensively by the indigenous Sámi people in the study area. The approximate density of wolverines were 1.4/100 km^2 in the study area (Persson et al. 2006).

Animal capture and monitoring

We monitored wolverines from 1993 to 2000. We captured and equipped juveniles (2–3 months old) with transmitters at rendezvous sites in early May to early June. All animals categorised as subadults were captured as juveniles and were hence of known age. Adults were captured on ground or were darted from helicopters (Arnemo and Fahlman 2007).

We radiotracked wolverines on average every second week by plane, complemented with additional ground-based telemetry. We estimated locations with triangulation (Kenward 2001), and the precision was given as estimated error-radius of 100-m intervals around the location. Reproduction of adult females was determined from documentation of denning behaviour or observations of offspring or their tracks by means of radiotracking and observations on the ground (Persson et al. 2006).

Home range sample requirements

We used minimum convex polygon (MCP) sample size bootstrap in Animal Movement Extension (Hooge and Eichenlaub 1997) to find the required sample size for annual home ranges (Harris et al. 1990; White and Garrott 1990; Kenward 2001). We were unable to find an asymptote in a number of telemetry locations, even when only adult resident individuals with ≥30 locations were used (n=15; 100 simulations). Therefore, we based sample size requirements for home range on a regression analysis to find a cut-off point where there was no positive correlation between home range size and number of locations (Dahl and Willebrand 2005).

Animals were considered resident if locations were strictly confined to a distinct area (Powell 2000). Furthermore, only resident animals that were alive and whose locations were distributed during the entire year under consideration were used. Annual home ranges were calculated in calendar years.

During 1993 to 2000, 24 individuals (17 females and seven males) fulfilled the stringent criteria for annual home range analyses and were used in analyses. Eleven individuals were monitored multiple years and provided sufficient data for multiple (two to four) estimates of home ranges. Their annual home ranges were used separately for comparison of different home range estimators (40 separate home ranges). Adult female home ranges from the same individual from different years were treated as individual units if they represented years with different reproductive status (reproductive or barren). However, when sufficient data were collected for a single individual for multiple years (with the same reproductive status), a mean annual home range was calculated (one barren and four reproducing adult females, two adult males) to avoid pseudoreplication.

Autocorrelation analyses

We used Schoeners' index (Schoener 1981; Swihart and Slade 1985) to control for autocorrelation in the location data (White and Garrott 1990; Kenward 2001). We calculated Schoeners' index for all individuals with annual home ranges and performed autocorrelation analyses with the Animal Movement Extension (Hooge and Eichenlaub 1997) in ArcView

3.2. We considered location data statistically autocorrelated when index values were below 1 (Kenward 2001).

Home range size

We estimated annual home ranges for all individuals that met the sample requirements. Home range estimators have different statistical properties, and a single method may not be appropriate to answer all research questions (Harris et al. 1990). Therefore, we used two statistically different methods: the MCP (Mohr 1947) and the fixed kernel method (FK; Worton 1989). We used 95% contours (FK95 and MCP95) to minimise influence of occasional excursions that could result in overestimates of range size (White and Garrott 1990). Fifty percent contours of kernel home ranges (FK50) were used as a measure of core area (Ackerman et al. 1990). Kernel estimators are suggested to be more accurate for estimation of home range size (Worton 1989; Seaman et al. 1999; Kernohan et al. 2001). Thus, home range sizes, overlaps, and relative differences between individuals of different sex and age are referred to FK95 estimates unless otherwise noted. We included MCP (100%) for comparison with previous studies (Harris et al. 1990).

Fixed kernels were created with least squares cross validation for selection of the smoothing parameter h (Seaman et al. 1999). Grid coarseness was allowed to vary across individuals. We performed all home range calculations in ArcView 3.2a (ESRI, Redlands, CA, USA) with Animal Movement Extension 2.0 (Hooge and Eichenlaub 1997) and Home Range Extension 0.9 (Rodgers and Carr 1998).

Home range overlaps

To examine territoriality, we calculated the proportion of exclusive home ranges and overlap between neighbouring individuals. Individuals were considered neighbours if they had contours (borders) within the distance of one home range radius (8 km). We quantified overlap of wolverine home ranges (FK95, MCP95), and core areas (FK50) were using theme-overlay routines in ArcView. We measured overlap size and calculated percent overlap of interacting individuals' home ranges as mean overlap and present it as an index (Minta 1992). We compared mean overlap in percent and size between age and sex categories. We calculated mean overlap as $= ([\text{overlap area}/\text{HRa}] \times [\text{overlap area}/\text{HRb}])^{0.5}$, where HR=home range, a=wolverine individual a, and b=wolverine individual b.

Temporal association in home range overlaps

We measured the proportion of locations that were temporally associated in overlap areas simultaneously within 24 h. Temporal association was calculated and quantified with simple ratio association indices (Cairns and Schwager 1987; Ginsberg and Young 1992). An index value of 1 indicates that all locations of both animals have been recorded at the same time in the overlap. A value of 0 indicates that individuals have not appeared in the overlap area during the same time. We assume that it is practically impossible to record an index value of 1 in the field. Therefore, we used a natural reference representing high association-level to evaluate the results. Association indices of each dyad were compared to a reference index calculated on interactions between wolverine mothers and their offspring during 1 year.

Simple ratio index was calculated as $= x/(x + y_{ab} + y_a + y_b)$, where a=wolverine individual a, b=wolverine individual b, x=number of locations of a and b together in the overlap area (within 24 h), y_{ab}=number of locations of a and b in respective home range outside overlap area, y_a=number of locations of a alone in overlap area, and y_b=number of locations of b alone in overlap area.

Statistical analyses

Because most data failed to approximate normal distributions and sample sizes were small, we used non-parametric tests (Siegel and Castellan 1988). Wilcoxon–Mann–Whitney two-tailed tests for small samples were used to test for differences between two independent groups. Kruskal–Wallis test was used when three or more groups were compared. Spearman's rank correlation was used to analyse correlation between home range size and number of locations. Statistical significance was inferred at an alpha level ≤0.05. All statistical analyses were performed in JMP 5.1 (SAS Institute 2000).

Results

We estimated 40 annual home ranges, which were used for comparison of home range estimators. After pooling multiple home ranges from the same individual, we used 28 home ranges from 20 adult wolverines for further analyses. We used 1,198 telemetry locations, and the mean triangulation error was estimated to be 583 m (SE±52). We used only locations with a triangulation error <1,000 m. Most (68%) locations were taken during March to August. Locations were reported to be autocorrelated for only two individuals (one adult female and one adult male). Location data from both individuals continued to show autocorrelation even when locations within 48 h were removed, most likely a result of some biological restrictions, and they were included in the analyses.

Home range size

At 20 locations, there was no positive correlation between fixed kernel range size and number of locations for adult reproducing females (Spearman's rank correlation; n=15, P=0.55, r_s=−0.1411), adult barren females (n=9, P=0.93, r_s=−0.035), or adult males (n=4, P=0.23, r_s=−0.5798). The result was similar for MCP. Thus, we considered a minimum of 20 locations sufficient for estimating annual home range size. However, one subadult resident female with 16 locations was included because no subadult females had ≥20 locations.

Estimates of annual home range (n=40) sizes differed significantly between methods (MCP100, MCP95, and FK95; Kruskal–Wallis test; P=0.043). The fixed kernel (95) method generated larger home ranges on average than both polygon estimates (MCP100 and MCP95 pooled; Wilcoxon–Mann–Whitney; P=0.035).

Mean annual home range size (FK95; Table 1) of adult males (n=4) was 669 km^2 (median 599 km^2) and ranged from 230–1,246 km^2. Mean home range size (FK95) of adult barren females (n=9) was 171 km^2 and ranged from 25–603 km^2. Mean home range size (FK95) for reproducing females (n=15) was 170 km^2 and ranged from 48–805 km^2. Median home range size (FK95) was 105 and 80 km^2 for reproducing and barren females, respectively. Because neither mean (the same) nor median (Wilcoxon–Mann–Whitney; P=0.57) home range size differed between barren and reproducing females, all females were pooled and compared to adult male home range size. Adult males had significantly larger home ranges than adult females (Wilcoxon–Mann–Whitney; P=0.001).

Core areas (FK50) of adults were 15–20% of total home range size, for both males and females (Table 1). There was no difference in core area size between the two classes of females (Wilcoxon–Mann–Whitney; P=0.52).

Annual home range sizes for resident subadult males (165 km^2) were approximately one third of adult ranges. One female resident subadult had a home range of 51 km^2. Core areas of subadults were 40% for males and 25% for the female.

Home range overlaps

Home range overlap differed depending on the home range estimation method used (Table 2). Fixed kernel 95 resulted in a total of 40 overlaps, while MCP95 generated only 13 overlaps. Sixteen adult females provided 30 pairs of neighbouring home ranges (same year). Ten (33%) home range pairs were exclusive, and 20 overlapped. Home range overlaps between adult females were generally small, with a mean overlap of 9% (Fig. 1; Table 2). Overlap sizes ranged from 0.01 to 46 km^2 and covered at most 24% of both female home ranges. Core areas were generally exclusive between adult females except for one case. However, this overlap (0.1 km^2) was an artefact generated by overlapping buffers (smoothing) around the locations. Annual home ranges of adult males (n=6) were totally exclusive. However, there were only two neighbouring males in 1993 and three neighbouring males in 1994.

Home range overlaps (Table 2) between adult males and adult females (n=10) were significantly larger than those between adult females (Wilcoxon–Mann–Whitney; P=0.018). Overlap sizes were up to 259 km^2 and covered at most 48% of both home ranges. One male was partly covering home ranges of five adult females, and another male overlapped three females within his home range. One female home range was totally enclosed by a male home range.

The largest overlaps were found between two pairs of subadult and adult males, covering an average of 29% of integrated home ranges (Table 2). Overlap sizes were 61 and 164 km^2, respectively. Mean overlap of adult females and subadult males (20%) were similar to those of adult males and females (0.17), but overlap sizes were smaller, probably because of relatively smaller home ranges. The subadult female had her home exclusive of other marked individuals throughout the year, but this was expected because there were no other marked individuals close to her home range.

Temporal association in home range overlaps

Wolverines were present simultaneously, within 24 h, in only 30% of overlapping FK home ranges (n=40). With MCP95 home ranges, the corresponding numbers were four

Table 1 Home range sizes of radiotracked wolverines (1993–2000) estimated with the minimum convex polygon method (MCP100 and MCP95) and the fixed kernel method (FK95)

Sex (status)	Age	Number	Number of telemetry locations	MCP100	MCP95	FK95	FK50	Autocorrelation
Females (reproducing)	Adult	15	29 (2)	131 (34)	99 (23)	170 (51)	30 (10)	1.7 (0.1)
Females (barren)	Adult	9	30 (2)	132 (58)	104 (45)	171 (63)	24 (10)	1.7 (0.2)
Females	Subadult	1	16	42	23	51	11	1.7
Males	Adult	4	26 (1)	403 (53)	434 (143)	669 (211)	105 (38)	1.4 (0.2)
Males	Subadult	3	23 (5.1)	140 (35)	110 (26)	165 (23)	66 (47)	1.7 (0.3)

Fifty percent fixed kernel contours (FK50) were used to estimate core areas of home ranges. All home range estimates are given as mean square kilometre (±SE). Autocorrelation (Schoener's index) and number of telemetry positions are given as mean (±SE)

Table 2 Home range overlaps of radiotracked wolverines (1993–2000) estimated with the fixed kernel method using the 95% (FK95) and 50% contours (FK50) and minimum convex polygon method (MCP95)

Dyad	FK95			MCP95			FK50		
	Number	Area	Proportion	Number	Size	Proportion	Number	Size	Proportion
♀♀	20	14 (3)	0.09 (0.07)	6	10 (5)	0.09	1	0.1	0.02
♂♀	10	66 (24)	0.17 (0.15)	3	109 (57)	0.29	0		
♂♂	0			0			0		
Subadult ♀–Adult ♀	0			0			0		
Subadult ♀–Adult ♂	0			0			0		
Subadult ♂–Adult ♂	2	113 (51)	0.29 (0.13)	1	46	0.17	1	12	0.09
Subadult ♂–Adult ♀	8	23 (7)	0.20 (0.22)	3	22 (8)	0.40	2	3 (2)	0.11

Overlap sizes are given as mean area (square kilometre; ±SE) and mean proportion (±SE). Dyad types consider adults if nothing else are given

out of 13 overlaps (31%). Temporal association generally resulted in low simple ratio index values compared to the reference index (Table 3).

Adult males and females showed the highest temporal association (0.11). On seven different occasions (2 and 5 days, respectively), two pairs were recorded simultaneously in the overlap area. Association took place during May and July (Fig. 2). When home ranges were analysed with the MCP95 method, association between adult males and females was also recorded in August.

Temporal association was found on five occasions in home range overlaps of four adult females. The association index was relatively low (0.06). Overlaps were often caused by short visits into the neighbouring home range, resulting in a low temporal association. Temporal association was recorded from July to December (Fig. 2).

Temporal association was found between three subadult males and five adults. One subadult male stayed for most of the year within an adult male home range, resulting in an index value of 0.074. Both individuals were recorded twice simultaneously in the overlap, one time in April and one time in August. Another four cases of temporal associations were found between four adult females and two subadult males, resulting in a relatively low index value of 0.065. Temporal association took place during February to September.

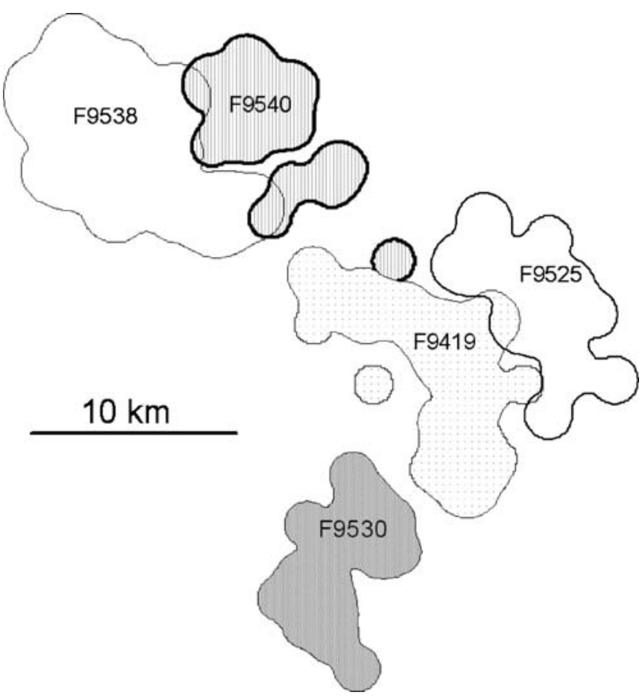

Fig. 1 Spatial distribution of five adult female wolverine home ranges (fixed kernel 95%) and their overlap during 1995 in Sarek, northern Sweden

Discussion

Home range size

Wolverines in our study showed considerable variation in home range size, within and among age and sex groups, ranging from 25–1,246 km^2. Mean annual home range size of adult males (669 km^2) was significantly larger than those of females (170 km^2). Home range sizes in this study are within the range of those of North American wolverines, although variation is large within and among studies (Appendix). Variation in home range sizes among studies may partly be related to differences in area characteristics such as abundance and distribution of food, but also differences in data collection, analyses, and sample sizes (Banci 1994; Harestad and Bunnell 1979).

Male wolverines had 3.9 times larger home ranges than females. This agrees with the polygamous mating system (Hedmark et al. 2007) and the social organisation of most solitary carnivores (Sandell 1989). Hence, male home range size is expected to be influenced by the density of females. It has been suggested that males increase their movements during

Table 3 Temporal association recorded in home range overlaps of radiotracked wolverines (1993–2000)

Dyad	FK95		MCP95		FK50	
	Number of temporal association/total	Simple ratio index	Number of temporal association/total	Simple ratio index	Number of temporal association/total	Simple ratio index
♀♀	4/20 (0.20)	0.056	0/20	–	0/20	–
♂♀	2/9 (0.22)	0.114	2/9 (0.22)	0.139	0/9	–
♂♂	0/0	–	0/0	–	0/0	–
Subadult ♀–Adult ♀	0/0	–	0/0	–	0/0	–
Subadult ♀–Adult ♂	0/0	–	0/0	–	0/0	–
Subadult ♂–Adult ♂	1/2 (0.50)	0.074	0/2	–	0/2	–
Subadult ♂–Adult ♀	4/8 (0.50)	0.065	2/8 (0.25)	0.103	0/8	–
Reference index	6/6 (1.0)	0.571				

Number of overlaps where temporal association was found is compared to the total number of overlaps (parenthesis). Temporal association among dyads is compared to a reference index (juveniles-mothers) representing high association. Temporal associations were recorded in home range overlaps calculated with the fixed kernel method with 95% (FK95) and 50% (FK50) contours and the minimum convex polygon method (MCP95)

the mating season (Hornocker and Hash 1981; Copeland 1996) possibly influencing annual range size. Female home range size is assumed to be related to distribution and availability of food (Magoun 1985; Banci 1994).

Both home range size and core areas of reproducing females were similar to that of barren females, even though the majority of telemetry locations were taken during the cub-rearing period (March to August). In contrast, previous studies suggest that females with offspring restrict their movements resulting in smaller home ranges (Magoun 1985; Banci 1994; Copeland 1996). It can be problematic to determine home range size for wolverine individuals without known residency status, and it is possible that previous studies include transient females in estimates of barren female home ranges (e.g., Hornocker and Hash 1981), which could explain larger home range sizes in barren females than reproducing females in previous studies. In this study, we included only females of known residency status in the analyses. Two reproductive females lost their cubs in April to May and would therefore only be restricted in their movements during a short period. They did not, however, have larger home ranges than other reproductive females. Furthermore, our study population is largely saturated with female territories giving little room for females to expand home ranges years without offspring if we assume territoriality. In lower density populations, home ranges might be more flexible between years. Two females in this study had unusually large home ranges (603 and 805 km^2). This was presumably the result of extraterritorial excursions preceding territory shifting the following year. However, excluding these females from the home range analysis did not affect the results significantly.

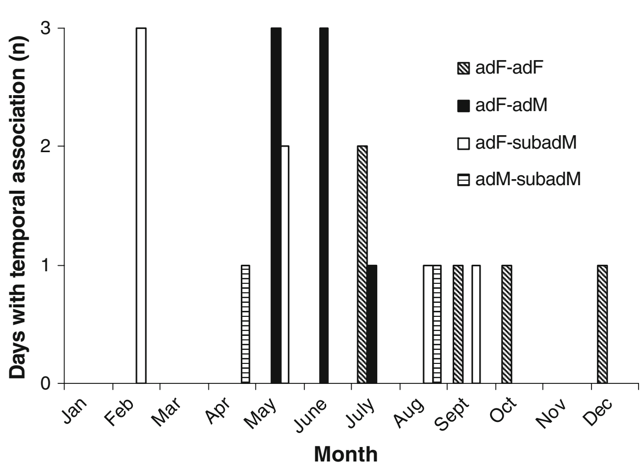

Fig. 2 Number of days and monthly distribution of temporal association recorded in home range overlaps (FK95) of wolverines in Sarek, northern Sweden (1993–2000). Dyads: *adF* adult female, *adM* adult male, and *subadM* subadult male

Home range overlaps

As expected, adult males and females had relatively large home range overlaps. One male partly covered home ranges of five adult females, and another male had three females within his home range. Similarly, one adult male in Alaska covered four to six females (Magoun 1985), and male home ranges encompassed those of three different females in Yukon and Idaho, respectively (Banci 1987; Copeland 1996). This suggests that female home ranges underlie the distribution of male home ranges in accordance with the wolverine mating system (Hedmark et al. 2007).

Home ranges of adult males were found to be exclusive. Sandell (1989) suggested that evenly distributed resources for males (i.e., females) may explain exclusive home ranges. Adult female home ranges were basically distributed border-to-border. Adult females had small overlaps, and core areas were always exclusive. This is consistent with previous studies where females maintained home ranges essentially exclusive throughout the year (Magoun 1985; Banci 1987; Copeland 1996). However, a relatively large overlap (26 km^2) was found between two reproducing females. Genetic analyses showed that these two females were most likely mother and daughter (Hedmark et al. 2007), presumably explaining greater tolerance.

Subadult and adult home ranges showed relatively large overlaps, similar to previous studies (Magoun 1985; Banci 1987; Copeland 1996). Adults seem to be tolerant towards subadults of the opposite sex. Furthermore, at least four out of ten subadult-adult overlaps were between closely related individuals. Of two opposite sex overlaps, one was between father and son, and three relatively large overlaps between subadult males and adult females were mother-son associations. In addition to opposite sex tolerance and kinship, it is possible that tolerance is given to subadults because they are of lower rank than adults and not considered competitors. Genovesi et al. (1997) suggested that spatial behaviour in stone martens (*Martes foina*) is influenced by age-related social ranking. Erlinge (1977) showed that resident adult and dominant male stouts (*Mustela erminea*) were relatively unconcerned with subadult males within their home ranges. However, juvenile and subadult wolverines are occasionally killed by conspecifics (Persson et al. 2003; Lofroth 2001), suggesting that non-related wolverines of all ages can be seen as competitors.

Temporal association

Temporal association indicates whether wolverines avoid each other in space and time. We found temporal association in only 30% of all home range overlaps in the population. Temporal association generally showed low values (Table 3) indicating strong territoriality and that home range overlaps were caused by few and brief visits into neighbouring home ranges, when the owners were in another part of its home range. However, low values of temporal association could be a result of relatively few telemetry locations.

Temporal association between adult males and females were documented from May to July. This coincides with the mating season (Rausch and Pearson 1972). Temporal associations between adult females were found from July to December. Landa et al. (1998) showed that resident females increase their activity in late fall (September to November) when their offspring were independent. It is also possible that increased movement at this time is related to foraging and food hoarding, before the winter, as food availability during winter is critical for female wolverine reproductive success (Persson 2005).

Maintenance of territoriality

Wolverines are assumed to keep home ranges separated in space and time by marking the boundaries with scent, urine, and excrements (Koehler et al. 1980). In addition, direct aggression presumably an important role in maintaining exclusive territories. Juvenile (Persson et al. 2003) and adult females (Persson et al. 2009) are killed by conspecifics. Persson et al. (2003) suggested that unrelated territorial females killed four juvenile females when they left their maternal home ranges in August to September. Furthermore, adult males frequently exhibit fresh scars and wounds during the mating season (Magoun 1985; Wedholm 2006), and intraspecific mortality among subadult and adult males have been documented during the mating season (Lofroth 2001; Persson et al. 2009), which suggests that males become aggressive and intolerant of intruders during the mating season. Hence, assuming that intraspecific strife primarily involves individuals of the same sex, we suggest that both male and female wolverines use aggression to defend their territories. Because males and females compete for different resources, it seems plausible that aggression is pronounced at different times of the year for each sex.

Conclusion

Knowledge of wolverine space use and social organisation derived from this study increases our understanding of why and how individuals are distributed in a wolverine population. Knowledge of home range size and use is necessary for deciding appropriate management scale for the species. Understanding home range size and territoriality can help us to predict effects of management actions, such as harvest. It can also contribute to improvements of monitoring methods. More research is needed to find what specific resources or social attributes (e.g., kinship) determine territorial behaviour and dynamics. Identifying these attributes could simplify conservation of wolverines, e.g., understanding the consequences of removal of individuals and how this affects the stability within populations. Advances in DNA-identification techniques and the development of global positioning system transmitters will give opportunities to study territoriality in more detail.

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Appendix

Table 4 Annual home ranges (square kilometre) of wolverine in different study areas

Location	Number	Mean	Range	Reference
Adult males				
Idaho, USA	5	1,506[a]	953–2,400	Copeland 1996
NW Alaska, USA	4	666	488–917	Magoun 1985
SC Norway	4	663	502–942	Landa et al. 1998
SC Alaska, USA	4	535[b]	340–620	Whitman et al. 1986
N Sweden	6	510	133–1,131	This study
Montana, USA	3	422[c]	–	Hornocker and Hash 1981
SW Yukon, Canada	1	238[e]	–	Banci 1987
Adult reproducing females				
Idaho, USA	2	273[a]	107–438	Copeland 1996
N Sweden	3	170[d]	109–221	Bjärvall 1982
N Sweden	15	131	31–560	This study
SC Alaska, USA	3	105[b]	60–120	Whitman et al. 1986
NW Alaska, USA	3	73	55–99	Magoun 1985
SW Yukon, Canada	1	47[e]	–	Banci 1987
Adult barren females				
SC Norway	4	335	273–397	Landa et al. 1998
Idaho, USA	4	320[a]	108–413	Copeland 1996
SW Yukon, Canada	2	155[e]	153–157	Banci 1987
NW Alaska, USA	6	126	56–232	Magoun 1985
N Sweden	9	132	45–576	This study
Subadult males				
SW Yukon	3	534	438–619	Banci 1987
Idaho	1	526		Copeland 1996
N Sweden	3	140	76–196	This study
Subadult females				
SW Yukon	2	476	370–582	Banci 1987
SC Norway	1	153		Landa et al. 1998
NW Alaska, USA	1	53		Magoun 1985
N Sweden	1	42		

All estimates are MCP100, unless nothing else is given

[a] Estimated with MCP95

[b] Estimates derived from logarithmic curve analyses of home range size vs time of monitoring

[c] Estimated on locations from more than 1 year

[d] Estimates based on snow-tracking

[e] Estimates excluding long excursions

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ORIGINAL PAPER

Space use and territoriality of wolverines (*Gulo gulo*) in northern Scandinavia

Jens Persson · Per Wedholm · Peter Segerström

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Abstract Space use and territoriality influence population structure and dynamics and is therefore an important aspect in understanding the ecology of animals. We investigated spatial and temporal space use of wolverines (*Gulo gulo*) in northern Scandinavia. We estimated home ranges of 24 radio-marked individuals (17 females and seven males). Male home ranges (mean 669 km^2; SE=211) were significantly larger than female home ranges (mean 170 km^2; Wilcoxon–Mann–Whitney; P=0.001) and encompassed or included parts of up to five different females. Home range sizes of reproducing (170 km^2; SE=51) and barren (171 km^2; SE=63) adult females did not differ. Wolverines in Scandinavia exhibit intrasexual territoriality, with male home ranges totally exclusive and female home ranges either exclusive or with little home range overlap. Overlap between wolverine territories is most likely explained by intrasexual tolerance and kinship.

Keywords Carnivore · Home range · Mustelid · Overlap · Social organisation

Introduction

The spacing pattern of animals is the result of the tactics used by individual animals in their attempts to survive and maximise reproductive success (Sandell 1989). Animals compete for different resources, such as food, shelter, and mates (Maher and Lott 1995). One way to compete is to exclude potential competitors from the area containing the resources (i.e., being territorial; Noble 1939; Schoener 1968; Brown and Orians 1970). A home range is defined as the area covered by the animals in their normal day-to-day activities and territory as that area which is defended against conspecifics (Burt 1943). Variation in home range size may lead to unequal division of resources among competitors, resulting in differential rates of growth, mortality, and reproduction (Adams 2001). Territorial behaviour can, thus, have strong effects on population structure and dynamics and is an important aspect in understanding animal ecology (Adams 2001).

The wolverine (*Gulo gulo*) is a solitary generalist predator and scavenger, occupying tundra, taiga, and forest zones of North America and Eurasia (Banci 1994). Because wolverine populations generally occur at low densities and occupy remote and rugged habitats, few studies of free-ranging wolverines have been conducted. Only in recent years has fundamental knowledge on wolverine demography been gained (Persson et al. 2003, 2006, 2009; Krebs et al. 2004; Persson 2005). Published information about wolverine spatial dynamics originates from a few telemetry studies (Hornocker and Hash 1981; Whitman et al. 1986; Landa et al. 1998; Vangen et al. 2001).

Like most mustelids (Powell 1979), wolverines exhibit intrasexual territoriality and varying degrees of intrasexual overlap (Banci 1994). Spatial organisation in solitary carnivores is determined by different resources for each sex; female home ranges would be determined by food resources while male home ranges would be determined by the number and distribution of females (Sandell 1989). This corresponds with the polygamous mating system of wolverines, which predicts that male home ranges should be larger than females (Hedmark et al. 2007).

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J. Persson (✉) · P. Segerström
Grimsö Wildlife Research Station, Department of Ecology,
Swedish University of Agricultural Sciences,
730 91 Riddarhyttan, Sweden
e-mail: jens.persson@ekol.slu.se

P. Wedholm
Örebro County Administrative Board,
Stortorget 22,
701 86 Örebro, Sweden

Globally, the wolverine is classified as vulnerable (Mustelid Specialist Group 1996). Conservation concerns include primarily habitat fragmentation, overexploitation, and depredation conflicts with sheep and reindeer husbandry (Landa et al. 2000; Slough 2007; Zhang et al. 2007). The Scandinavian wolverine population's distribution and size declined markedly during the 1900s (Flagstad et al. 2004). Currently, ≥1/2 of the Scandinavian wolverine population, estimated at about 780 individuals, reside in Sweden (Persson 2007) where it is classified as endangered (Gärdenfors 2000). The distribution of wolverines in Sweden largely overlaps with that of semi-domestic reindeer (*Rangifer tarandus*), which is the predominant prey of wolverines (Persson 2005). Locally, reindeer husbandry suffers from heavy predation by wolverines and other predators (Swenson and Andrén 2005). As a result, poaching and lethal control forms a substantial part of wolverine population dynamics in northern Scandinavia (Persson et al. 2009).

In light of current conflicts and lack of knowledge, more information is needed to understand spatial ecology of wolverines and to enable sound management of the species. Therefore, in this study, we examine space use and social organisation in wolverines. In particular, we assess age and sex specific home range size and territoriality.

Materials and methods

Study area

This study was conducted in and around Sarek National Park in northern Sweden above the Arctic Circle (Kvikkjokk: 67°00′N, 17°40′E). The climate is continental, and the ground is usually snow-covered from November to late May. The area is characterised by deep valleys, glaciers, and high alpine plateaus with peaks ≤2,000 m above sea level. The valleys are dominated by mountain birch (*Betula pubescens*), Scots pine (*Pinus sylvestris*), and Norway spruce (*Picea abies*), while mountain birch forms the tree line at 600–700 m above sea level (Grundsten 1997). Semi-domestic reindeer are managed exclusively and extensively by the indigenous Sámi people in the study area. The approximate density of wolverines were 1.4/100 km^2 in the study area (Persson et al. 2006).

Animal capture and monitoring

We monitored wolverines from 1993 to 2000. We captured and equipped juveniles (2–3 months old) with transmitters at rendezvous sites in early May to early June. All animals categorised as subadults were captured as juveniles and were hence of known age. Adults were captured on ground or were darted from helicopters (Arnemo and Fahlman 2007).

We radiotracked wolverines on average every second week by plane, complemented with additional ground-based telemetry. We estimated locations with triangulation (Kenward 2001), and the precision was given as estimated error-radius of 100-m intervals around the location. Reproduction of adult females was determined from documentation of denning behaviour or observations of offspring or their tracks by means of radiotracking and observations on the ground (Persson et al. 2006).

Home range sample requirements

We used minimum convex polygon (MCP) sample size bootstrap in Animal Movement Extension (Hooge and Eichenlaub 1997) to find the required sample size for annual home ranges (Harris et al. 1990; White and Garrott 1990; Kenward 2001). We were unable to find an asymptote in a number of telemetry locations, even when only adult resident individuals with ≥30 locations were used (n=15; 100 simulations). Therefore, we based sample size requirements for home range on a regression analysis to find a cut-off point where there was no positive correlation between home range size and number of locations (Dahl and Willebrand 2005).

Animals were considered resident if locations were strictly confined to a distinct area (Powell 2000). Furthermore, only resident animals that were alive and whose locations were distributed during the entire year under consideration were used. Annual home ranges were calculated in calendar years.

During 1993 to 2000, 24 individuals (17 females and seven males) fulfilled the stringent criteria for annual home range analyses and were used in analyses. Eleven individuals were monitored multiple years and provided sufficient data for multiple (two to four) estimates of home ranges. Their annual home ranges were used separately for comparison of different home range estimators (40 separate home ranges). Adult female home ranges from the same individual from different years were treated as individual units if they represented years with different reproductive status (reproductive or barren). However, when sufficient data were collected for a single individual for multiple years (with the same reproductive status), a mean annual home range was calculated (one barren and four reproducing adult females, two adult males) to avoid pseudoreplication.

Autocorrelation analyses

We used Schoeners' index (Schoener 1981; Swihart and Slade 1985) to control for autocorrelation in the location data (White and Garrott 1990; Kenward 2001). We calculated Schoeners' index for all individuals with annual home ranges and performed autocorrelation analyses with the Animal Movement Extension (Hooge and Eichenlaub 1997) in ArcView

3.2. We considered location data statistically autocorrelated when index values were below 1 (Kenward 2001).

Home range size

We estimated annual home ranges for all individuals that met the sample requirements. Home range estimators have different statistical properties, and a single method may not be appropriate to answer all research questions (Harris et al. 1990). Therefore, we used two statistically different methods: the MCP (Mohr 1947) and the fixed kernel method (FK; Worton 1989). We used 95% contours (FK95 and MCP95) to minimise influence of occasional excursions that could result in overestimates of range size (White and Garrott 1990). Fifty percent contours of kernel home ranges (FK50) were used as a measure of core area (Ackerman et al. 1990). Kernel estimators are suggested to be more accurate for estimation of home range size (Worton 1989; Seaman et al. 1999; Kernohan et al. 2001). Thus, home range sizes, overlaps, and relative differences between individuals of different sex and age are referred to FK95 estimates unless otherwise noted. We included MCP (100%) for comparison with previous studies (Harris et al. 1990).

Fixed kernels were created with least squares cross validation for selection of the smoothing parameter *h* (Seaman et al. 1999). Grid coarseness was allowed to vary across individuals. We performed all home range calculations in ArcView 3.2a (ESRI, Redlands, CA, USA) with Animal Movement Extension 2.0 (Hooge and Eichenlaub 1997) and Home Range Extension 0.9 (Rodgers and Carr 1998).

Home range overlaps

To examine territoriality, we calculated the proportion of exclusive home ranges and overlap between neighbouring individuals. Individuals were considered neighbours if they had contours (borders) within the distance of one home range radius (8 km). We quantified overlap of wolverine home ranges (FK95, MCP95), and core areas (FK50) were using theme-overlay routines in ArcView. We measured overlap size and calculated percent overlap of interacting individuals' home ranges as mean overlap and present it as an index (Minta 1992). We compared mean overlap in percent and size between age and sex categories. We calculated mean overlap as $=([\text{overlap area}/\text{HRa}]\times[\text{overlap area}/\text{HRb}])^{0.5}$, where HR=home range, a=wolverine individual a, and b=wolverine individual b.

Temporal association in home range overlaps

We measured the proportion of locations that were temporally associated in overlap areas simultaneously within 24 h. Temporal association was calculated and quantified with simple ratio association indices (Cairns and Schwager 1987; Ginsberg and Young 1992). An index value of 1 indicates that all locations of both animals have been recorded at the same time in the overlap. A value of 0 indicates that individuals have not appeared in the overlap area during the same time. We assume that it is practically impossible to record an index value of 1 in the field. Therefore, we used a natural reference representing high association-level to evaluate the results. Association indices of each dyad were compared to a reference index calculated on interactions between wolverine mothers and their offspring during 1 year.

Simple ratio index was calculated as $=x/(x+y_{ab}+y_a+y_b)$, where a=wolverine individual a, b=wolverine individual b, x=number of locations of a and b together in the overlap area (within 24 h), y_{ab}=number of locations of a and b in respective home range outside overlap area, y_a=number of locations of a alone in overlap area, and y_b=number of locations of b alone in overlap area.

Statistical analyses

Because most data failed to approximate normal distributions and sample sizes were small, we used non-parametric tests (Siegel and Castellan 1988). Wilcoxon–Mann–Whitney two-tailed tests for small samples were used to test for differences between two independent groups. Kruskal–Wallis test was used when three or more groups were compared. Spearman's rank correlation was used to analyse correlation between home range size and number of locations. Statistical significance was inferred at an alpha level ≤0.05. All statistical analyses were performed in JMP 5.1 (SAS Institute 2000).

Results

We estimated 40 annual home ranges, which were used for comparison of home range estimators. After pooling multiple home ranges from the same individual, we used 28 home ranges from 20 adult wolverines for further analyses. We used 1,198 telemetry locations, and the mean triangulation error was estimated to be 583 m (SE±52). We used only locations with a triangulation error <1,000 m. Most (68%) locations were taken during March to August. Locations were reported to be autocorrelated for only two individuals (one adult female and one adult male). Location data from both individuals continued to show autocorrelation even when locations within 48 h were removed, most likely a result of some biological restrictions, and they were included in the analyses.

Home range size

At 20 locations, there was no positive correlation between fixed kernel range size and number of locations for adult reproducing females (Spearman's rank correlation; n=15, P=0.55, r_s=−0.1411), adult barren females (n=9, P=0.93, r_s=−0.035), or adult males (n=4, P=0.23, r_s=−0.5798). The result was similar for MCP. Thus, we considered a minimum of 20 locations sufficient for estimating annual home range size. However, one subadult resident female with 16 locations was included because no subadult females had ≥20 locations.

Estimates of annual home range (n=40) sizes differed significantly between methods (MCP100, MCP95, and FK95; Kruskal–Wallis test; P=0.043). The fixed kernel (95) method generated larger home ranges on average than both polygon estimates (MCP100 and MCP95 pooled; Wilcoxon–Mann–Whitney; P=0.035).

Mean annual home range size (FK95; Table 1) of adult males (n=4) was 669 km^2 (median 599 km^2) and ranged from 230–1,246 km^2. Mean home range size (FK95) of adult barren females (n=9) was 171 km^2 and ranged from 25–603 km^2. Mean home range size (FK95) for reproducing females (n=15) was 170 km^2 and ranged from 48–805 km^2. Median home range size (FK95) was 105 and 80 km^2 for reproducing and barren females, respectively. Because neither mean (the same) nor median (Wilcoxon–Mann–Whitney; P=0.57) home range size differed between barren and reproducing females, all females were pooled and compared to adult male home range size. Adult males had significantly larger home ranges than adult females (Wilcoxon–Mann–Whitney; P=0.001).

Core areas (FK50) of adults were 15–20% of total home range size, for both males and females (Table 1). There was no difference in core area size between the two classes of females (Wilcoxon–Mann–Whitney; P=0.52).

Annual home range sizes for resident subadult males (165 km^2) were approximately one third of adult ranges. One female resident subadult had a home range of 51 km^2. Core areas of subadults were 40% for males and 25% for the female.

Home range overlaps

Home range overlap differed depending on the home range estimation method used (Table 2). Fixed kernel 95 resulted in a total of 40 overlaps, while MCP95 generated only 13 overlaps. Sixteen adult females provided 30 pairs of neighbouring home ranges (same year). Ten (33%) home range pairs were exclusive, and 20 overlapped. Home range overlaps between adult females were generally small, with a mean overlap of 9% (Fig. 1; Table 2). Overlap sizes ranged from 0.01 to 46 km^2 and covered at most 24% of both female home ranges. Core areas were generally exclusive between adult females except for one case. However, this overlap (0.1 km^2) was an artefact generated by overlapping buffers (smoothing) around the locations. Annual home ranges of adult males (n=6) were totally exclusive. However, there were only two neighbouring males in 1993 and three neighbouring males in 1994.

Home range overlaps (Table 2) between adult males and adult females (n=10) were significantly larger than those between adult females (Wilcoxon–Mann–Whitney; P=0.018). Overlap sizes were up to 259 km^2 and covered at most 48% of both home ranges. One male was partly covering home ranges of five adult females, and another male overlapped three females within his home range. One female home range was totally enclosed by a male home range.

The largest overlaps were found between two pairs of subadult and adult males, covering an average of 29% of integrated home ranges (Table 2). Overlap sizes were 61 and 164 km^2, respectively. Mean overlap of adult females and subadult males (20%) were similar to those of adult males and females (0.17), but overlap sizes were smaller, probably because of relatively smaller home ranges. The subadult female had her home exclusive of other marked individuals throughout the year, but this was expected because there were no other marked individuals close to her home range.

Temporal association in home range overlaps

Wolverines were present simultaneously, within 24 h, in only 30% of overlapping FK home ranges (n=40). With MCP95 home ranges, the corresponding numbers were four

Table 1 Home range sizes of radiotracked wolverines (1993–2000) estimated with the minimum convex polygon method (MCP100 and MCP95) and the fixed kernel method (FK95)

Sex (status)	Age	Number	Number of telemetry locations	MCP100	MCP95	FK95	FK50	Autocorrelation
Females (reproducing)	Adult	15	29 (2)	131 (34)	99 (23)	170 (51)	30 (10)	1.7 (0.1)
Females (barren)	Adult	9	30 (2)	132 (58)	104 (45)	171 (63)	24 (10)	1.7 (0.2)
Females	Subadult	1	16	42	23	51	11	1.7
Males	Adult	4	26 (1)	403 (53)	434 (143)	669 (211)	105 (38)	1.4 (0.2)
Males	Subadult	3	23 (5.1)	140 (35)	110 (26)	165 (23)	66 (47)	1.7 (0.3)

Fifty percent fixed kernel contours (FK50) were used to estimate core areas of home ranges. All home range estimates are given as mean square kilometre (±SE). Autocorrelation (Schoener's index) and number of telemetry positions are given as mean (±SE)

Table 2 Home range overlaps of radiotracked wolverines (1993–2000) estimated with the fixed kernel method using the 95% (FK95) and 50% contours (FK50) and minimum convex polygon method (MCP95)

Dyad	FK95			MCP95			FK50		
	Number	Area	Proportion	Number	Size	Proportion	Number	Size	Proportion
♀♀	20	14 (3)	0.09 (0.07)	6	10 (5)	0.09	1	0.1	0.02
♂♀	10	66 (24)	0.17 (0.15)	3	109 (57)	0.29	0		
♂♂	0			0			0		
Subadult ♀–Adult ♀	0			0			0		
Subadult ♀–Adult ♂	0			0			0		
Subadult ♂–Adult ♂	2	113 (51)	0.29 (0.13)	1	46	0.17	1	12	0.09
Subadult ♂–Adult ♀	8	23 (7)	0.20 (0.22)	3	22 (8)	0.40	2	3 (2)	0.11

Overlap sizes are given as mean area (square kilometre; ±SE) and mean proportion (±SE). Dyad types consider adults if nothing else are given

out of 13 overlaps (31%). Temporal association generally resulted in low simple ratio index values compared to the reference index (Table 3).

Adult males and females showed the highest temporal association (0.11). On seven different occasions (2 and 5 days, respectively), two pairs were recorded simultaneously in the overlap area. Association took place during May and July (Fig. 2). When home ranges were analysed with the MCP95 method, association between adult males and females was also recorded in August.

Temporal association was found on five occasions in home range overlaps of four adult females. The association index was relatively low (0.06). Overlaps were often caused by short visits into the neighbouring home range, resulting in a low temporal association. Temporal association was recorded from July to December (Fig. 2).

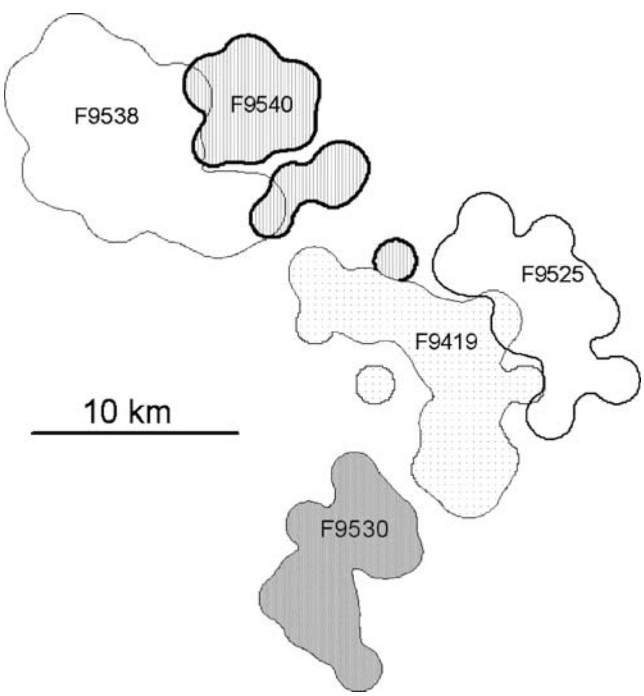

Fig. 1 Spatial distribution of five adult female wolverine home ranges (fixed kernel 95%) and their overlap during 1995 in Sarek, northern Sweden

Temporal association was found between three subadult males and five adults. One subadult male stayed for most of the year within an adult male home range, resulting in an index value of 0.074. Both individuals were recorded twice simultaneously in the overlap, one time in April and one time in August. Another four cases of temporal associations were found between four adult females and two subadult males, resulting in a relatively low index value of 0.065. Temporal association took place during February to September.

Discussion

Home range size

Wolverines in our study showed considerable variation in home range size, within and among age and sex groups, ranging from 25–1,246 km^2. Mean annual home range size of adult males (669 km^2) was significantly larger than those of females (170 km^2). Home range sizes in this study are within the range of those of North American wolverines, although variation is large within and among studies (Appendix). Variation in home range sizes among studies may partly be related to differences in area characteristics such as abundance and distribution of food, but also differences in data collection, analyses, and sample sizes (Banci 1994; Harestad and Bunnell 1979).

Male wolverines had 3.9 times larger home ranges than females. This agrees with the polygamous mating system (Hedmark et al. 2007) and the social organisation of most solitary carnivores (Sandell 1989). Hence, male home range size is expected to be influenced by the density of females. It has been suggested that males increase their movements during

Table 3 Temporal association recorded in home range overlaps of radiotracked wolverines (1993–2000)

Dyad	FK95		MCP95		FK50	
	Number of temporal association/total	Simple ratio index	Number of temporal association/total	Simple ratio index	Number of temporal association/total	Simple ratio index
♀♀	4/20 (0.20)	0.056	0/20	–	0/20	–
♂♀	2/9 (0.22)	0.114	2/9 (0.22)	0.139	0/9	–
♂♂	0/0	–	0/0	–	0/0	–
Subadult ♀–Adult ♀	0/0	–	0/0	–	0/0	–
Subadult ♀–Adult ♂	0/0	–	0/0	–	0/0	–
Subadult ♂–Adult ♂	1/2 (0.50)	0.074	0/2	–	0/2	–
Subadult ♂–Adult ♀	4/8 (0.50)	0.065	2/8 (0.25)	0.103	0/8	–
Reference index	6/6 (1.0)	0.571				

Number of overlaps where temporal association was found is compared to the total number of overlaps (parenthesis). Temporal association among dyads is compared to a reference index (juveniles-mothers) representing high association. Temporal associations were recorded in home range overlaps calculated with the fixed kernel method with 95% (FK95) and 50% (FK50) contours and the minimum convex polygon method (MCP95)

the mating season (Hornocker and Hash 1981; Copeland 1996) possibly influencing annual range size. Female home range size is assumed to be related to distribution and availability of food (Magoun 1985; Banci 1994).

Both home range size and core areas of reproducing females were similar to that of barren females, even though the majority of telemetry locations were taken during the cub-rearing period (March to August). In contrast, previous studies suggest that females with offspring restrict their movements resulting in smaller home ranges (Magoun 1985; Banci 1994; Copeland 1996). It can be problematic to determine home range size for wolverine individuals without known residency status, and it is possible that previous studies include transient females in estimates of

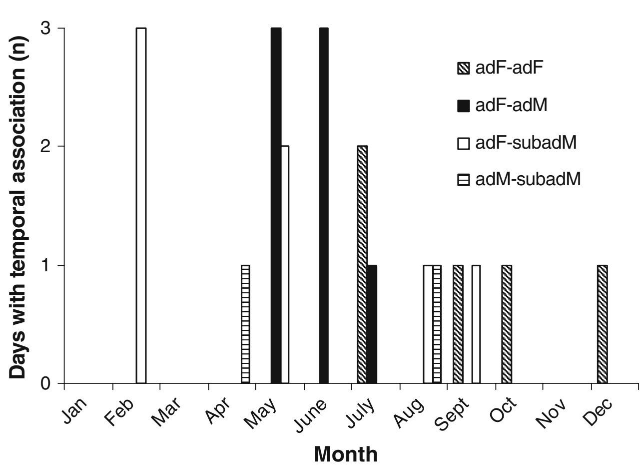

Fig. 2 Number of days and monthly distribution of temporal association recorded in home range overlaps (FK95) of wolverines in Sarek, northern Sweden (1993–2000). Dyads: *adF* adult female, *adM* adult male, and *subadM* subadult male

barren female home ranges (e.g., Hornocker and Hash 1981), which could explain larger home range sizes in barren females than reproducing females in previous studies. In this study, we included only females of known residency status in the analyses. Two reproductive females lost their cubs in April to May and would therefore only be restricted in their movements during a short period. They did not, however, have larger home ranges than other reproductive females. Furthermore, our study population is largely saturated with female territories giving little room for females to expand home ranges years without offspring if we assume territoriality. In lower density populations, home ranges might be more flexible between years. Two females in this study had unusually large home ranges (603 and 805 km^2). This was presumably the result of extraterritorial excursions preceding territory shifting the following year. However, excluding these females from the home range analysis did not affect the results significantly.

Home range overlaps

As expected, adult males and females had relatively large home range overlaps. One male partly covered home ranges of five adult females, and another male had three females within his home range. Similarly, one adult male in Alaska covered four to six females (Magoun 1985), and male home ranges encompassed those of three different females in Yukon and Idaho, respectively (Banci 1987; Copeland 1996). This suggests that female home ranges underlie the distribution of male home ranges in accordance with the wolverine mating system (Hedmark et al. 2007).

Home ranges of adult males were found to be exclusive. Sandell (1989) suggested that evenly distributed resources for males (i.e., females) may explain exclusive home ranges. Adult female home ranges were basically distributed border-to-border. Adult females had small overlaps, and core areas were always exclusive. This is consistent with previous studies where females maintained home ranges essentially exclusive throughout the year (Magoun 1985; Banci 1987; Copeland 1996). However, a relatively large overlap (26 km^2) was found between two reproducing females. Genetic analyses showed that these two females were most likely mother and daughter (Hedmark et al. 2007), presumably explaining greater tolerance.

Subadult and adult home ranges showed relatively large overlaps, similar to previous studies (Magoun 1985; Banci 1987; Copeland 1996). Adults seem to be tolerant towards subadults of the opposite sex. Furthermore, at least four out of ten subadult-adult overlaps were between closely related individuals. Of two opposite sex overlaps, one was between father and son, and three relatively large overlaps between subadult males and adult females were mother-son associations. In addition to opposite sex tolerance and kinship, it is possible that tolerance is given to subadults because they are of lower rank than adults and not considered competitors. Genovesi et al. (1997) suggested that spatial behaviour in stone martens (*Martes foina*) is influenced by age-related social ranking. Erlinge (1977) showed that resident adult and dominant male stouts (*Mustela erminea*) were relatively unconcerned with subadult males within their home ranges. However, juvenile and subadult wolverines are occasionally killed by conspecifics (Persson et al. 2003; Lofroth 2001), suggesting that non-related wolverines of all ages can be seen as competitors.

Temporal association

Temporal association indicates whether wolverines avoid each other in space and time. We found temporal association in only 30% of all home range overlaps in the population. Temporal association generally showed low values (Table 3) indicating strong territoriality and that home range overlaps were caused by few and brief visits into neighbouring home ranges, when the owners were in another part of its home range. However, low values of temporal association could be a result of relatively few telemetry locations.

Temporal association between adult males and females were documented from May to July. This coincides with the mating season (Rausch and Pearson 1972). Temporal associations between adult females were found from July to December. Landa et al. (1998) showed that resident females increase their activity in late fall (September to November) when their offspring were independent. It is also possible that increased movement at this time is related to foraging and food hoarding, before the winter, as food availability during winter is critical for female wolverine reproductive success (Persson 2005).

Maintenance of territoriality

Wolverines are assumed to keep home ranges separated in space and time by marking the boundaries with scent, urine, and excrements (Koehler et al. 1980). In addition, direct aggression presumably an important role in maintaining exclusive territories. Juvenile (Persson et al. 2003) and adult females (Persson et al. 2009) are killed by conspecifics. Persson et al. (2003) suggested that unrelated territorial females killed four juvenile females when they left their maternal home ranges in August to September. Furthermore, adult males frequently exhibit fresh scars and wounds during the mating season (Magoun 1985; Wedholm 2006), and intraspecific mortality among subadult and adult males have been documented during the mating season (Lofroth 2001; Persson et al. 2009), which suggests that males become aggressive and intolerant of intruders during the mating season. Hence, assuming that intraspecific strife primarily involves individuals of the same sex, we suggest that both male and female wolverines use aggression to defend their territories. Because males and females compete for different resources, it seems plausible that aggression is pronounced at different times of the year for each sex.

Conclusion

Knowledge of wolverine space use and social organisation derived from this study increases our understanding of why and how individuals are distributed in a wolverine population. Knowledge of home range size and use is necessary for deciding appropriate management scale for the species. Understanding home range size and territoriality can help us to predict effects of management actions, such as harvest. It can also contribute to improvements of monitoring methods. More research is needed to find what specific resources or social attributes (e.g., kinship) determine territorial behaviour and dynamics. Identifying these attributes could simplify conservation of wolverines, e.g., understanding the consequences of removal of individuals and how this affects the stability within populations. Advances in DNA-identification techniques and the development of global positioning system transmitters will give opportunities to study territoriality in more detail.

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Appendix

Table 4 Annual home ranges (square kilometre) of wolverine in different study areas

Location	Number	Mean	Range	Reference
Adult males				
Idaho, USA	5	1,506[a]	953–2,400	Copeland 1996
NW Alaska, USA	4	666	488–917	Magoun 1985
SC Norway	4	663	502–942	Landa et al. 1998
SC Alaska, USA	4	535[b]	340–620	Whitman et al. 1986
N Sweden	6	510	133–1,131	This study
Montana, USA	3	422[c]	–	Hornocker and Hash 1981
SW Yukon, Canada	1	238[e]	–	Banci 1987
Adult reproducing females				
Idaho, USA	2	273[a]	107–438	Copeland 1996
N Sweden	3	170[d]	109–221	Bjärvall 1982
N Sweden	15	131	31–560	This study
SC Alaska, USA	3	105[b]	60–120	Whitman et al. 1986
NW Alaska, USA	3	73	55–99	Magoun 1985
SW Yukon, Canada	1	47[e]	–	Banci 1987
Adult barren females				
SC Norway	4	335	273–397	Landa et al. 1998
Idaho, USA	4	320[a]	108–413	Copeland 1996
SW Yukon, Canada	2	155[e]	153–157	Banci 1987
NW Alaska, USA	6	126	56–232	Magoun 1985
N Sweden	9	132	45–576	This study
Subadult males				
SW Yukon	3	534	438–619	Banci 1987
Idaho	1	526		Copeland 1996
N Sweden	3	140	76–196	This study
Subadult females				
SW Yukon	2	476	370–582	Banci 1987
SC Norway	1	153		Landa et al. 1998
NW Alaska, USA	1	53		Magoun 1985
N Sweden	1	42		

All estimates are MCP100, unless nothing else is given

[a] Estimated with MCP95

[b] Estimates derived from logarithmic curve analyses of home range size vs time of monitoring

[c] Estimated on locations from more than 1 year

[d] Estimates based on snow-tracking

[e] Estimates excluding long excursions

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Attachment _EM_ (6).joboptions (5397 Bytes) cannot be converted to PDF format.

From: Grizzle, Betty
To: A J
Subject: Re:
Date: Thursday, June 29, 2017 12:23:01 PM

Great! Thanks again.

On Thu, Jun 29, 2017 at 11:17 AM, A J <222wsheridan@gmail.com> wrote:

> This may be the paper I was thinking of---see Table 1.

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

From: Grizzle, Betty
To: A J
Subject: Re:
Date: Thursday, June 29, 2017 12:33:23 PM

Thanks for emphasizing this. I am looking at this estimate relative to physical landscape features surrounding natal den sites, not to estimate populations or density.

On Thu, Jun 29, 2017 at 11:28 AM, A J <222wsheridan@gmail.com> wrote:

> Betty
> I think some of the disparity between 95 and 100% MCP for lactating females is caused by location of food sources while raising the young. The female home range in Ontario jumped up to almost twice as much in the 100% MCP when she traveled to an area she had not previously gone previously to get parts of a beaver carcass that the resident male cached there (he was at the den just the day after making the beaver kill and she went there while he was at the den and I suspect she followed his tracks back there). Food location is important in determining home range when the female's are raising young and may not be an accurate picture of their normal home range outside of the Feb-July period. Using home range of lactating females to determine carrying capacity for reproductive females would overestimate habitat potential, I believe, because food distribution and abundance could change between years. It would be very hard to tease apart the various factors that are affecting home range size (density) without knowing residency in the whole area. That is one key point in Malin's thesis.

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

From: A J
To: Grizzle, Betty; Robert Inman
Subject: Fwd: Myhr
Date: Thursday, June 29, 2017 12:57:21 PM

Translator

---------- Forwarded message ----------
From: **Martin Robards** <mrobards@wcs.org>
Date: Thu, Jun 29, 2017 at 10:55 AM
Subject: Re: Myhr
To: A J <222wsheridan@gmail.com>
Cc: Mirjam Barrueto <m.barrueto@yahoo.com>

Audrey and Mirjam,

Ann Olsson did the translation for me. She was a UAF grad student in Biology and Wildlife and Swedish so a logical choice!

M

On Thu, Jun 29, 2017 at 10:01 AM, A J <222wsheridan@gmail.com> wrote:

> Mirjam
> Here is the translation of the Myhr paper. Martin Robards arranged the translation. We should find out the full name of the translator to give her credit if this paper is cited as a translation.
>
> Click here to report this email as spam.

--
Dr. Martin Robards
Director, Arctic Beringia Program
Wildlife Conservation Society
Cell: +1 (907) 750-9991

Web Site: http://www.wcs.org/our-work/regions/arctic-beringia
Field Blog: arcticberingia.wordpress.com
Programmatic Blog: http://arcticberingia.exposure.co
Twitter: https://twitter.com/ArcticWCS

From:	Brent Esmoil
To:	Justin Shoemaker; Betty Grizzle
Subject:	Draft Wolverine BP for review
Date:	Thursday, June 29, 2017 1:30:13 PM
Attachments:	WOLVERINE INFO MEMO FOR THE DEPUTY ASSISTANT SECRETARY_20170705.docx
Importance:	High

Betty and Justin:

Could you take a quick look at the attached draft and let me know your thoughts regarding its readiness for submission? Feel free to edit at will. Thanks!

Brent Esmoil
Deputy Field Supervisor
U.S. Fish and Wildlife Service
Montana ES Field Office
585 Shephard Way, Suite 1
Helena, Montana 59601
406-449-5225, ext. 215
www.fws.gov/montanafieldoffice

INFORMATION MEMORANDUM FOR THE DEPUTY ASSISTANT SECRETARY

DATE: July 5, 2017

FROM: Noreen Walsh, Regional Director, Mountain-Prairie Region, 303-236-7920

SUBJECT: Status Review for the North American Wolverine

I. STATEMENT OF PURPOSE

This memorandum provides an update to the Secretary regarding the status review underway for the North American wolverine (*Gulo gulo luscus*; wolverine) under the Endangered Species Act (Act).

II. BACKGROUND

In compliance with the April 4, 2016, Montana District Court's order that vacated our previous withdrawal of a proposed rule (published August 13, 2014) to list the contiguous U.S. Distinct Population Segment (DPS) of the North American wolverine; we are conducting a status review for the species and preparing a Species Status Assessment (SSA) Report. For the SSA Report, we are reviewing previously considered as well as new information to address the Court's concerns and are using the best available information upon which to base our listing decision.

III. DISCUSSION

Highlighted in the Court's order were the U. S. Fish and Wildlife Service's determinations regarding: (a) the threat posed to the wolverine by the effects of climate change at the reproductive denning scale, (b) the threat posed to the wolverine by small population size and lack of genetic diversity, and (c) application of the Significant Portion of its Range (SPR) Policy to the wolverine. In our SSA Report, we are reviewing previously considered and new information to address the Court's concerns and we are using the best available information upon which to base our listing decision.

IV. NEXT STEPS

- Since the publication of the 2013 proposed rule (February 4, 2013), several new wolverine studies have been published, which have added to our understanding of wolverine biology while also highlighting new insights into identifying key species' needs and their interactions with both abiotic and biotic factors.
- The SSA Report will be submitted to independent peer reviewers and to Federal, State, and other partners to evaluate the scientific accuracy of the report. We expect that submission to occur in late October.

- We will prepare either a revised proposed rule to list or a revised withdrawal of the previous proposed rule in early 2018.

V. **ATTACHMENTS** – N/A

From:	Grizzle, Betty
To:	Brent Esmoil
Cc:	Justin Shoemaker
Subject:	Re: Draft Wolverine BP for review
Date:	Thursday, June 29, 2017 1:35:31 PM
Attachments:	WOLVERINE INFO MEMO FOR THE DEPUTY ASSISTANT SECRETARY_20170705_BJGedits.docx

Just a few suggestions. See attached.

On Thu, Jun 29, 2017 at 12:30 PM, Brent Esmoil <brent_esmoil@fws.gov> wrote:

> Betty and Justin:
>
> Could you take a quick look at the attached draft and let me know your thoughts regarding its readiness for submission? Feel free to edit at will. Thanks!
>
> Brent Esmoil
>
> Deputy Field Supervisor
>
> U.S. Fish and Wildlife Service
>
> Montana ES Field Office
>
> 585 Shephard Way, Suite 1
>
> Helena, Montana 59601
>
> 406-449-5225, ext. 215
>
> www.fws.gov/montanafieldoffice

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
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V. **ATTACHMENTS** – N/A

From:	Shoemaker, Justin
To:	Grizzle, Betty
Cc:	Brent Esmoil
Subject:	Re: Draft Wolverine BP for review
Date:	Thursday, June 29, 2017 1:43:02 PM
Attachments:	WOLVERINE INFO MEMO FOR THE DEPUTY ASSISTANT SECRETARY_20170705_BJGedits_JMSedits.docx

A couple more suggestions added to Betty's version.

Justin Shoemaker
Classification and Recovery Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

On Thu, Jun 29, 2017 at 2:35 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:

> Just a few suggestions. See attached.
>
> On Thu, Jun 29, 2017 at 12:30 PM, Brent Esmoil <brent_esmoil@fws.gov> wrote:
>
>> Betty and Justin:
>>
>> Could you take a quick look at the attached draft and let me know your thoughts regarding its readiness for submission? Feel free to edit at will.   Thanks!
>>
>> Brent Esmoil
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>> Deputy Field Supervisor
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>>
>> 585 Shephard Way, Suite 1
>>
>> Helena, Montana 59601
>>
>> 406-449-5225, ext. 215
>>
>> www.fws.gov/montanafieldoffice
>
> --
>
> Betty J. Grizzle, D.Env.
> Fish and Wildlife Biologist

U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
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760-431-9440, ext. 215
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INFORMATION MEMORANDUM FOR THE DEPUTY ASSISTANT SECRETARY

DATE: July 5, 2017

FROM: Noreen Walsh, Regional Director, Mountain-Prairie Region, 303-236-7920

SUBJECT: Status Review for the North American Wolverine

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Formatted: Line spacing: single

II. BACKGROUND

In compliance with the April 4, 2016, Montana District Court's order that vacated our previous withdrawal of a proposed rule (published August 13, 2014) to list the contiguous U.S. Distinct Population Segment (DPS) of the ~~North American~~ wolverine; we are conducting a status review for the species and preparing a Species Status Assessment (SSA) Report. The SSA Report will provide the scientific basis for our upcoming listing decision. ~~For the SSA Report, we are reviewing previously considered as well as new information to address the Court's concerns and are using the best available information upon which to base our listing decision.~~

III. DISCUSSION

Highlighted in the Court's order were the U. S. Fish and Wildlife Service's determinations regarding: (a) the threat posed to the wolverine by the effects of climate change at the reproductive denning scale, (b) the threat posed to the wolverine by small population size and lack of genetic diversity, and (c) application of the Significant Portion of its Range (SPR) Policy to the wolverine. In our SSA Report, we are reviewing previously considered and new information to address the Court's concerns and we are using the best available information upon which to base our listing decision. Since the publication of the 2013 proposed rule (February 4, 2013), several new wolverine studies have been published, which have added to our understanding of wolverine biology while also highlighting new insights into identifying key species' needs and their interactions with both abiotic and biotic factors.

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- The SSA Report will be submitted to independent peer reviewers and to Federal, State, and Tribal?other partners to evaluate the scientific accuracy of the report. We expect that submission to occur in late October.
- We will prepare either a revised proposed rule to list or a revised withdrawal of the previous proposed rule in early 2018.

V. **ATTACHMENTS** – N/A

From: Brent Esmoil
To: Justin Shoemaker; Betty Grizzle
Subject: RE: Draft Wolverine BP for review
Date: Thursday, June 29, 2017 1:51:39 PM

Thanks to both of you for the speedy review. Now I'll see if I can get it to one page.

Brent Esmoil
Deputy Field Supervisor
U.S. Fish and Wildlife Service
Montana ES Field Office
585 Shephard Way, Suite 1
Helena, Montana 59601
406-449-5225, ext. 215
www.fws.gov/montanafieldoffice

From: Shoemaker, Justin [mailto:justin_shoemaker@fws.gov]
Sent: Thursday, June 29, 2017 1:42 PM
To: Grizzle, Betty
Cc: Brent Esmoil
Subject: Re: Draft Wolverine BP for review

A couple more suggestions added to Betty's version.

Justin Shoemaker
Classification and Recovery Biologist
U.S. Fish and Wildlife Service, Region 6
Phone: 309-757-5800 x214
Email: justin_shoemaker@fws.gov

On Thu, Jun 29, 2017 at 2:35 PM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:
Just a few suggestions. See attached.

On Thu, Jun 29, 2017 at 12:30 PM, Brent Esmoil <brent_esmoil@fws.gov> wrote:
Betty and Justin:

Could you take a quick look at the attached draft and let me know your thoughts regarding its readiness for submission? Feel free to edit at will. Thanks!

Brent Esmoil
Deputy Field Supervisor
U.S. Fish and Wildlife Service
Montana ES Field Office
585 Shephard Way, Suite 1
Helena, Montana 59601
406-449-5225, ext. 215
www.fws.gov/montanafieldoffice

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Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

From:	A J
To:	Grizzle, Betty
Subject:	Re: Myhr translation
Date:	Thursday, June 29, 2017 2:45:48 PM

Yes

Sent from my iPhone

On Jun 29, 2017, at 11:27 AM, Grizzle, Betty <betty_grizzle@fws.gov> wrote:

> Thanks Audrey. Is this a translation of the following?
>
> Myhr, T-M. 2015. Järvhonors rörelsemönster kring lyplatsen under lyperioden. BSc. SLU.
>
> [English] Myhr, T-M. 2015 Movement pattern of wolverine females around the den during the denning period. BSc. SLU (in Swedish).
>
> On Thu, Jun 29, 2017 at 11:34 AM, A J <222wsheridan@gmail.com> wrote:
>
> > Betty and Bob
> > I can't recall if I sent you this translation. I am trying to get Anna's full name so she can get credit for translating if her translation is used as a reference.
>
> --
>
> Betty J. Grizzle, D.Env.
> Fish and Wildlife Biologist
> U.S. Fish and Wildlife Service
> Carlsbad Fish and Wildlife Office
> 2177 Salk Ave, Suite 250
> Carlsbad, CA 92008
> 760-431-9440, ext. 215
> 760-431-5901 fax

From:	Joe Barsugli
To:	Guinotte, John; Stephen Torbit; Andrea Ray
Subject:	Fwd: wolverine (status of ROMO 1 meter diagnosis)
Date:	Wednesday, July 5, 2017 5:06:31 PM

John, (cc: Steve, Andrea)

I mentioned that I would have a status report on the ROMO issues on Wednesday -- Here is a forward from Ben and Aaron regarding some runs to diagnose the effect of canopy. Keep in mind two things -- one is that SNOTEL sites are preferentialy in clearings which tend to accumulate more snow than the surrounding forest, but also, that clearings also exist in the forest in non-SNOTEL sites -- so that this sort of variation does occur. I hope we will have these simulations to work with before the meeting, but if not, I will have a written description of the "logic" of what could be causing the results (meteorological inputs, model physics, canopy,...) and what we are able to say about each step.

Joe

-------- Forwarded Message --------

Subject: wolverine
Date: Wed, 5 Jul 2017 15:38:17 -0600
From: Ben Livneh <Ben.Livneh@colorado.edu>
Reply-To: Ben.Livneh@colorado.edu
To: Joseph Barsugli - NOAA Affiliate <joseph.barsugli@noaa.gov>

Hi Joe,

Aaron has been working intensively to re-run the veg-free simulations over the past week. He ran into a persistent runtime error, which has caused us to go back and look at the trail of simulations. We are working through to make sure we did what we thought we did, and I hope to have an update on that by Friday.

Thanks,
Ben

--
Ben Livneh, Ph.D
Assistant Professor, Department of Civil, Environmental, and Architectural Engineering
&
Fellow, Cooperative Institute for Research in Environmental Sciences (CIRES)
Campus Box 216 UCB, Ekeley S250C, University of Colorado, Boulder 80309, USA
Phone: 303-735-0288 | http://www.colorado.edu/lab/livneh/

--
Joseph Barsugli, Research Scientist III
CIRES, UCB216
University of Colorado Boulder
Boulder CO 80309

303-497-6042
PSD Science Board and
Attribution and Predictability Assessments Team Member

From:	Grizzle, Betty
To:	Shoemaker, Justin
Subject:	Draft Current Range Map
Date:	Friday, July 14, 2017 9:04:51 AM
Attachments:	Wolverine_Curent_Range.pdf

See attached, which is based on several different sources. (Note: we also have a historical "range" map, but that needs more explanation).

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

U.S. Fish & Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave. Suite 250, Carlsbad, California 92008

DRAFT Not for real use yet....

PRODUCED BY GIS SERVICES
CARLSBAD FIELD OFFICE
GIS CONTACT: ED TURNER
BIOLOGY CONTACT: BETTY GRIZZLE
(760) 431-9440
DATA SOURCE: USFWS, NWT, USCB, ESRI
IMAGE SOURCE: ESRI Online Mapper
Apr 27, 2017
S:\stem\edstemp\American_wolverine\MXDs\SSA_FINAL\Wolverine_Curent_Range_Portrait.mxd

N

0 90 180 360 Miles

0 90 180 360 Kilometers

Legend

North American Wolverine (*Gulo gulo luscus*) Current Range

From: Guinotte, John
To: Stephen Torbit
Subject: report edits
Date: Sunday, July 16, 2017 7:26:22 AM
Attachments: Wolverine Report Text FINAL DRAFT 5May17 (KED 17MAY) JMG(19MAY) JMG(15July).docx

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Hi Steve, I removed several of my comments in this version. I got rid of everything that had to do w 1m snow depth and also removed all requests related to analysis of inferred den elevation bands in ROMO. I still think they should go into more detail on den elevation bands in GLAC. We know they are there and it is relevant to the questions we are trying to answer. We can go into detail on the romo elevation bands in the SSA. Also, I think June 1 results still remain irrelevant in my opinion. I won't make a big deal about it if they leave them in, but they don't do us any good for wolverine. June 1 results could/should be included in the peer-reviewed publication. I think the only set of figs they need to add is the graphs with total area of snow, this is in addition to the percent cover change ones they already have done. Let me know if there is more you want me to do. I'm in Seattle now and flying to AK Sunday am, but will have a few hours on the plane to work on this and should have internet in Bethel so can send you something.

Best, John

John Guinotte
Spatial Ecologist
Ecological Services
U.S. Fish and Wildlife Service
Mountain Prairie Region 6
134 Union Blvd., Lakewood, CO 80228
303-236-4264
john_guinotte@fws.gov

Wolverine Snow Refugia Study: An analysis of future climate risks

A Report to the U.S. Fish and Wildlife Service Region 6

Andrea J. Ray[1], Joseph J. Barsugli[2], Ben Livneh[3] Candida F. Dewes[2], Imtiaz Rangwala[2], Aaron Heldmyer[3], Jenna Stewart[3]

[1]NOAA/ESRL/Physical Sciences Division
Boulder, CO
[2]CU/Cooperative Institute for Research in Environmental Sciences (CIRES)
[3]CU Civil, Environmental & Architectural Engineering

Corresponding Author:
Andrea
303-497-6434
andrea.ray@noaa.gov

JOHN Main Points for NOAA:

1. Replace all June 1 results w April 15. Drop June 1 entirely from report, no relevance to wolverine denning.
2. Copy den elevation stats from GLAC section into Exec Summary (comments inserted).
3. SWE to SD conversion needs to be put in early in report SD = (SWE X 2.5).
5. Make sure comparisons are consistent. McKelvey comparison should be to 13mm SWE. Snow depth (i.e. 0.5m-May 1 and 15) only used for denning discussion, not McKelvey
John to do: Pull SD for GLAC dens from DHSVM for April 15 and May 1 (This is Done)

KED Main Points:

- First off, Well done. This is a really cool report and gives a lot of insight that was not possible in past climate change reports! Throughout the report I have line by line COMMENTS in [CAPS] so they are easy to see.
- June 1st needs to be pulled form report. Based upon a denning report from Idaho, it seems like April 15th is the date when most dens are abandoned and 1-m of snow is the minimum denning depth (Magoun and Copeland 1998). There might be more info, but the point is June 1st is nowhere near this timeframe.

- Mckevley Comparisons:
  - MAY 15TH and 0.5m is an inferred metric trying to compare with McKelvey.
  - Comparisons need to be 13mm on May 15th.
    - Why you chose 13mm vs 5mm etc, needs to be explained not just stated. If the results are basically equivocal between the two break points, state it in

the report. People who do not like the management decision will come after any information that is used. Please be supper careful with words and give it one last read and make sure you explain all of the decisions.

- Denning Discussions:
  - We need to use 1m of snow and April 15th.

- Avoid language that is ambiguous in summary sections:
  - Instead of all lost SWE, or significant losses, Give the Range of the 5 GCM's and 3 weather patterns
  - Instead of saying "limited to refugia at two high elevation areas", Give the size of these areas vs. the size of the area you modeled snow.

- CUT topography section and graphs that are not standardized.

- The context of the GCM's are not discussed after CH2. Are they relevant to the main take home points in CH5?

- We need to be careful on the language. This document is likely going to be read in court and we don't want to leave things up for interpretation. We need to clearly say why we made our decisions.

  - Example Text "The period of the modeling study in Section 5 ends in 2013 due to dataset limitations, but it is worth noting that the last two years of the MODIS record, 2015 and 2016 show low snowcover."
  - We need explicitly say we could not use 2015 and 2016 because they did not include….
  - Another example would be our choice of elevation band for our study area. Etc..

Executive Summary

Overview: This study is a fine-scale assessment of snow extent and depth at two areas in and in the vicinity of Glacier (GLAC) and Rocky Mountain (ROMO) National Parks. The analysis was done for both the recent past, using MODIS satellite-based remote sensing, and in historic simulations and projections of future snowpack using a high-resolution hydrologic model. The fine scale hydrologic modeling allows for the consideration of snow processes such as dependence on terrain slope and aspect that are important to understanding high elevation snow persistence in a changing climate and were not considered in previous work.

Methods: The report intentionally builds on previous work by McKelvey et al. (2011) extending that work by providing a higher resolution spatial scale analysis for two case study areas, and a broader range of future scenarios. Two areas were studied: a high latitude, low elevation area within Glacier National Park (Figure 2-1) that is currently occupied by wolverines and a lower latitude, high elevation area within Rocky Mountain National Park (Figure 2-2). These sites were chosen to bracket the range of latitude and elevation wolverines currently occupy in the contiguous U.S. A detailed comparison of their methodologies and ours is provided in Table 2-1. The project uses methods from the peer-reviewed, published literature to:

- Explicitly model the effects of slope and aspect, using fine-scale spatial models to analyze topographic effects on snow
- Better represent the range of plausible future changes (climate scenarios)
- Analyze extremes: we selected representative wet, dry, and near normal years from the historic record and assessed how these might change in the future
  - Representative years for GLAC: 2011 (cool wet), 2005 (warm dry), 2009 (near normal).
  - Representative years for ROMO: 2011 (cool wet), 2002 (warm dry), 2007 (near normal).
- Assessing change in snow persistence by elevation, with emphasis on elevations used by wolverines for denning.

MODIS Observed Historic Snowpack Variability Analysis: Satellite-based MODIS snow cover data was used to assess the historical variability of snow cover in the study areas and as a basis for the spatial evaluation of the hydrologic model simulations. The historical observed snow cover was analyzed for its dependence on terrain elevation and aspect (compass direction that the slope faces).

- In GLAC, snow covered areavaries considerably by year, including “wet” years such as 2011 with very persistent snow, years with strong melt in early May, such as 2012, or in late May (2009, 2001), and “dry” years (2004, 2005). The period of the modeling study in Section 5 ends in 2013 due to dataset limitations, but it is worth noting that the last two years of the MODIS record, 2015 and 2016 show low snowcover (Section 4.3).
- Even in dry years, NE-facing slopes in GLAC tend to hold more snow and melt later in the season. There is > 80% snow cover above ~2000 m elevation on May 1 during dry years, and > 95% snow cover above ~1200 m during wet years. ~~Snow conditions on June 1 during wet years resemble those for May 1 during near-normal years.~~
- In ROMO, snow covered area also varies considerably by year (Section 4.4).
- NW-facing slopes in ROMO tend to hold more snow even during dry years. In very dry

Commented [GJM1]: June 1 is irrelevant for denning.

Commented [GJM2]: Add in context re known den elevations in GLAC years, snow cover peaks at intermediate elevations, suggesting that the high-altitude snowpack may be particularly vulnerable in this region under warm/dry conditions.

Future Snowpack Projections: The Distributed Hydrology Soil Vegetation (DHSVM) was run in historical simulations of the period 1998-2013. The model was validated against SNOTEL in-situ snow observations and MODIS snow cover. The model was then run for five scenarios of the future which represent a nominal 2055 climate. Scenarios were selected from CMIP5 global climate model (GCM) projections, and were chosen to span a large fraction of the range of the CMIP5 ensemble projections in each study area in terms of precipitation and temperature changes. Representative Wet, Near Normal, and Dry years were analyzed for the historical simulations and how each of these years plays out under these five future scenarios. The number of years (out of 16) with snow above 0.5m depth was also analyzed as was the change in Snow Covered Area (SCA) with depth greater than 0.5m. The average change in SCA and Snow Water Equivalent (SWE) was analyzed as a function of elevation, and for GLAC was overlayed with the elevations of wolverine den sites. (Section 5)

For the study area in Glacier National Park (GLAC), projections for May 15th Snow Covered Area and area with snow depth greater than 0.5 meters declines on average in all scenarios and for almost all years (Section 5-11). This is a 12-42 percent decline in snow covered area, and a 15-68 percent decline in area with snow depth > 0.5 meters for the scenarios considered.

- ~~The Warm/Wet scenario shows the least change compared to the historic snow cover in terms of the area of significant (0.5 meter) snowpack, comparable to only a small shift in time. In contrast, under the Hot/Wet scenario, on May 1 the area covered by >0.5 snowpack is smaller than the area covered on June 1 in the historic record – a shift of a month earlier.~~
- All projections show declines in the number of years with significant snow. The areas with frequent (14-16 years) availability of significant snow become concentrated in smaller high elevation areas. [ANOTHER WAY OF SAYING THIS IS LOWER ELEVATION AREAS HAD THE LARGEST CHANGE IN THE ESTIMATES] This phenomenon of elevation-dependent snowpack change in the Western US is well supported in the literature. Regonda et al. (2005) found little historical change in snowpack in the Western United States above approximately 2500m elevation despite observed warming trends.
- For wet years, the high elevations of the study areas result in little loss of snowpack under most scenarios of change.
- For high elevation areas, there is little change in SCA for 4 of the 5 scenarios above 2200m. ~~As in a mirror image there is greater than 95 % loss of SCA below 1400m for 4 of the 5 scenarios. Between these two elevations – and in the regions where most observations of dens have been noted – the snowpack change is very sensitive to elevation and to the particular future climate scenario~~. ALL BUT THREE DENS ARE BETWEEN 1800 AND 2000M. OF THOSE THAT ARE NOT 2 ARE ABOVE 2000M AND ONE IS BELOW ~1500M. 1800-2000 IS THE RELEVANT BAND FOR THE DATA WE HAVE.
- Figure 5-23 also illustrates that SWE can have modest declines without affecting the area with significant snow depth. The implications is that wet, cold climate of the GLAC study area can act as a "buffer" to change in the area of 0.5 meter deep snow on May 1st,

at least at high elevations.[MAIN POINT THROUGHOUT 1M APRIL 15 OR 13MM MAY 15]

For the study area in and around Rocky Mountain National Park (ROMO), projections of May 15th Snow Covered Area in ROMO (13mm threshold on May 15) declines on average in all scenarios and for almost all years. (Section 5-12)

- There is a 12-52 percent decline in snow covered area, and a 7-64 percent decline in area with snow depth > 0.5 meters for the scenarios considered.
- Snow Covered Area in ROMO (0.5 m threshold on May 15) generally declines in wet years, but may increase in dry years in those scenarios with increased precipitation.
- Some scenarios with increased precipitation show increases in May 15 snowpack at the higher elevations in both study areas, but decreases in snowpack at lower elevations. This can lead to an increase in the area of > 0.5 meters of snow for "dry" years.
- ROMO exhibited more uncertainty in projections than GLAC
    - ROMO has more uncertainty as to whether precipitation will increase or decrease.
    - The beneficial effect of increased precipitation on snowpack is more prominent earlier in the Spring. In the Warm/Wet scenario, the area of significant snow on May1 increases on average, though it decreases on May 15.
    - For wet years, the high elevations of the study areas result in only modest loss of snow cover under all scenarios of change. However even in wet years, the area of significant snowpack can decline by almost 50% for the Hot/Dry climate change scenario. (Section 5-X)

Elevation dependence of change (Section 5.13): **In general, and supported by the literature, the snowpack at the higher elevations of both areas is more responsive to precipitation change, while at lower elevations it is more responsive to temperature change**. For GLAC, most of the observed den sites are located [~100-300 meters??? Below] the precipitation-dominated zone, and therefore at elevations where the changes in snowpack are highly dependent on the climate scenario and also on elevation. For high elevation [DEFINE ELEVATION THRESHOLD AND REPORT THE STATS] areas there is loss of SCA [OF X to X% (or X to X% retention)]for four of the five future scenarios, with an increase only in the Warm/Wet (giss) scenario. The climate of ROMO is, on average drier than that of GLAC, and the regions of the model simulations that have significant snow [SIGNIFICANT IS NOT DEFINED] in most years is restricted to the two smaller areas[X-X % OF THE DOMAIN] within the domain (Figure 5-21). As a result the characteristics of the present-day climate does not act to buffer changes in the area of significant snow on May 1st as it does in GLAC.

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Comparison with McKelvey's results (Section 6): There are challenges in making a direct comparison between the studies due to differences in the goals and spatial scale. McKelvey investigated persistence of even a light snow cover to May 15th as a correlate of wolverine habitat, as noted in Aubry et al (2008). This study focuses on high-elevation terrain and on the persistence of deeper snowpack. However, the following comparisons are valid:

- Snow cover persists in our study areas, even for the hotter [HOTTEST?] scenario of change in the McKelvey study (miroc "2080's). The greatest loss of snow cover in McKelvey occurs at lower elevations that were deliberately not included in the GLAC or

ROMO study areas. [IF THIS STATEMENT STAYS YOU NEED TO DEFINE WHY THE ELEVATION BAND WAS CHOSEN]

- McKelvey focused exclusively on the persistence of even light snow cover on May 15th. Because of the increased resolution of our study we are able to consider whether any pockets of snow with depth greater than 0.5 meters will persist in these areas[1M DENNING APRIL 15TH]. Results vary according to scenario, but generally show declines in SCA with depth greater than 0.5 meters by the 2050s, as noted above.[GENERALLY SHOWS DECLINE IS NOT A GREAT SUMMARY STATEMENT, GIVE STATS EITHER X TO X% LOSS OR X TO X% RETENTION]
- Our results may reasonably be generalized to the high mountain ranges within the Rockies that lie between GLAC and ROMO, with projections on average wetter in GLAC. However, without further study we cannot reasonably extend our results to say whether or not snow refugia may persist in the Central Rockies at lower elevations [WITHOUT A DEFINITION OF ELEVATION YOU CANT INTERPRET THIS SENTENCE] where McKelvey indicates the greatest snowpack losses, nor to the Cascades with its very different maritime climate.

Commented [GJM3]: Should a bullet be added here to summarize the scale issue with McKelvey? 1 of 7 years of Modis snow "counts" as snow cover. Also, if a 500m modis cell was snow covered, the 6km cell it fell in counted as snow cover

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1 Introduction

1.1 Motivation

This report responds to the United States Fish and Wildlife Service (FWS) need for information on potential climate impacts to snow persistence. The North American wolverine (*Gulo gulo luscus*) is currently being evaluated for listing as a threatened or endangered species under the Endangered Species Act (ESA) and climate change effects on snow persistence was identified as an important factor for the future viability of the wolverine. The species was considered for listing in 2014, but FWS concluded that it did not warrant listing. They further concluded that there is significant uncertainty about how the effects of climate change will affect wolverines and their habitat in the foreseeable future, and that this uncertainty includes information on how fine-scale changes in snow cover and persistence might affect denning site selection.

This report provides FWS with a finer scale assessment of snow extent and depth at which extends previous work by McKelvey et al. (2011). We believe the inclusion of finer scale analyses as well as additional snow processes such as slope and aspect are critical to understanding high elevation snow persistence in a changing climate.

ADD By design, our methods are from the peer-reviewed, published literature, etc. What we find is consistent with past research

Funding was provided by the U.S. Fish and Wildlife Service, Region 6 and the NOAA/Earth System Research Lab/Physical Sciences Division. This effort builds on work underway by the project team at NOAA/ESRL/PSD, the NOAA-University of Colorado (CU) Cooperative Institute for Research in Environmental Sciences (CIRES), and CU Department of Civil, Environmental & Architectural Engineering.

1.2 Project Objectives

Persistent spring snowpack has been described as an important factor in determining suitable habitat for the wolverine, including Northern boreal forests and subarctic and alpine tundra (Aubry et al, 2007, Peacock et al, 2011). This relationship was the basis for the analysis by Copeland et al. (2010) and McKelvey et al. (2011) used in the previous FWS decision. In both studies, climate change projections of snowpack were used to characterize potential future wolverine habitat.

The goal of this effort is to identify the depth and persistence of spring snow in the future. Our primary objective is to advance scientific understanding of the current spatial extent of spring snow retention on the landscape, and the future temporal and spatial extent of snow retention through a thirty-year period, 2041-2070, centered on the year 2055. We aim to advance snow analysis and modeling to better support assessment of snow-related species, in the following ways:

- Explicitly model the effects of slope and aspect, using fine-scale spatial models to analyze topographic effects on snow

- Better represent the range of plausible future changes (climate scenarios)
- Analyze extremes: wet and dry years from the historic record and how these might change in the future [BOUND OUR UNCERTANTY??]

Our strategy was to build on previous methods where possible to be comparable to work by McKelvey et al. (2011) and Copeland et al. (2010). We departed from their methods where necessary to take advantage of analysis techniques not feasible at the large scales used in the studies done by those authors. These include new scientific data and tools that are now available, including the following:

- Use of a longer time series of satellite and in situ observations [JARGON DEFINE]
- Analysis of historic snowpack variability to investigate the influences of topography on snow cover
- Use of more recent climate model output and improved criteria for choice of climate change scenarios
- Use of hydrologic modeling at highly resolved (250m) spatial scale for simulation and future projection of snow cover and depth for two case study areas in Glacier National Park and Rocky Mountain National Park.

2 Project Overview and Background

2.1 Overview

We first reviewed the observed climate and variability, in order to provide context for future changes (Section 3). We next analyzed historic snow variability from satellite remote sensing of snow extent from the year 2000 to present to determine areas of greater and lesser sensitivity to climate drivers (temperature and precipitation), and identify possible snow refugia. Prior studies also show a relationship between terrain (slope and aspect) and persistence of snow (e.g. Lundquist and Flint, 2006) and thus this factor is potentially important under in a changed climate. (Section 4). We then did an intercomparison of the satellite observations of snow with that from the DHSVM hydrologic modeling study that includes a representation of slope and aspect (the compass direction that the slope faces) of the terrain and shading on the snowpack. Finally, the DSHVM hydrologic model was forced with five future scenarios of climate change for each of the two study regions (Section 5). These future climate scenarios were derived from the latest Coupled Model Inter-comparison Project Phase-5 runs (CMIP5, Taylor et al., 2012) which informed the latest Intergovernmental Panel on Climate Change (IPCC) report (IPCC AR5, 2013).

All methodologies were chosen to be consistent with those used in existing peer-reviewed work.

2.2 Study Areas

High-resolution hydrologic modeling was needed to provide fine scale analysis of snow. However, given time, funding and computational constraints, it was necessary to limit the study domain to two areas of about 1,500-3,000km^2 for high-resolution analysis. Two study areas representing core and peripheral habitat regions in the northern and central Rocky Mountains were identified in consultation with FWS Region 6 personnel (Figures 2-1 and 2-2). We bracketed the range [EXTENT-RANGE HAS OTHER MEANINGS TO LAWYERS] of wolverine habitat conditions in the lower 48 habitat conditions, because we were restricted to smaller areas for analysis. The two sites chosen included a high latitude, low elevation area within Glacier National Park (Figure 2-1) that is currently occupied by wolverines and a lower latitude, high elevation area within Rocky Mountain National Park (Figure 2-2) that has had recent documented wolverine occurrence and could be a potential reintroduction site for wolverines. Both model areas encompassed elevations from ~250m below treeline to maximum elevation.

The analysis for the GLAC and ROMO study areas is presented in separate sections, repeating descriptions to make the material self-contained for the reader who may read about only one area; similarly, complete captions are given for each area.

2.3 The West-wide context of future climate

Global climate models (GCMs) are the primary tools used by climate science to examine the nature of climate change during the 21st century. These models reveal both the uncertainty of climate projections as well as underlying regional patterns of change. This section provides a west-wide context for the specific choices of future climate scenarios that will be discussed later in the report.

Understanding the uncertainty of climate projections is commonly approached through comparison of the results from multiple climate models (e.g. IPCC, 2013). There are currently about 20 modeling centers worldwide that provide output from their best model or models to be considered in the Coupled Model Inter-comparison Project Phase-5 (CMIP5, Taylor et al., 2012), an international, coordinated modeling project which informed the most recent Intergovernmental Panel on Climate Change (IPCC) assessment report (IPCC AR5, 2013). When we quantify regional changes in climate variables such as temperature and precipitation by a particular time horizon in the 21st century, we find a large spread in the extent of warming and changes in precipitation, including both increases and decreases in precipitation, as shown in regional maps (Figure 2-4 [FIGURE 2-3 IS NOT REFERENCE AND LABELED WRONG AS FIGURE 2-4]) and described later in Section 5. For temperature change, much of this spread (or uncertainty) is a result of the difference among the formulations of the GCMs (e.g., their climate sensitivities), whereas for precipitation it is both the differences among GCMs and internal climate variability. Some difference also comes out of the choice of future greenhouse gases (GHG) emission scenario. However, the differences among greenhouse gas emissions scenarios is less at mid-21st century compared to later in the century, and is much smaller than other sources of uncertainty at the regional scale (IPCC,2013).

In addition to uncertainty, the CMIP5 climate models also reveal regional patterns of change. Figure 2-4 shows projected annual and seasonal temperature and precipitation changes by 2050 (2035–2064) over the western U.S., including the northern and central Rocky Mountains, from an ensemble of the 34 climate models used for this study under the RCP 8.5, a high-end emissions scenario. The large maps show the average change for all of the models (n=34) for that season, and the small maps show the average changes of the highest 20% and lowest 20% of the models, based on the statewide change for Colorado in temperature or precipitation. For much of the central and northern Rockies, all models show a substantial warming (of +2.5°F to +5.5°F). While fewer models agree about the direction of precipitation change west-wide, even the lower (drier) models show an increase in winter precipitation for the area around Glacier National Park, although there is less agreement for the central Rockies area including Rocky Mountain National Park. [ROMO IN CO LOOKS LIKE ANYWHERE BETWEEN MUCH WETTER IN THE WINTER AND SPRING TO NO CHANGE IN PRECIPITATION WITH AVERAGES OF 5-15% INCREASES.—LOOKING AT THIS IT'S A SHAME WE DID NOT DO A HOT/VERY WET SCENARIO. FOR ROMO-IS WARM/WET THE AVERAGE CLIMATE PREDICTION??---LOOKS LIKE ABOUT THE SAME FOR GLAC…]

The uncertainty of climate change motivates the choice of several future climate scenarios for each study region. The regional patterns of change indicate that the range of the climate scenarios chosen will differ somewhat from region to region. The GCM output, and the specific selection of future climate scenarios for this study are discussed further in Section 5.

2.4 Comparison between our analysis and that of Copeland and McKelvey

The Copeland et al. (2010) and McKelvey et al. (2011) studies were an integral part of the previous FWS decision process. Therefore, we present here a detailed comparison of their methodologies and ours, to establish both how our methodologies followed theirs when appropriate, and diverged where new data or updated methods were available. A summary of the most salient similarities and differences between our work and the studies used previously is presented in Table 2-1.

Table 2-1: Modeling Methods Compared to McKelvey

	McKelvey (Littell)	**This Study**
Spatial Resolution (modeling)	VIC model – 1/16 degree (~5km x 7 km, ~37km^2 cell)	DHSVM model - 250m x 250m UTM grid (~0.0625 km^2 cell)
Spatial Extent	Westwide except California and Great Basin	ROMO and GLAC study areas, near and above treeline
Process differences	Slope and aspect were not modeled and the mountains were assumed to be flat from a solar radiation process, implicit elevation bands.	Slope, aspect, shading, explicit fine scale elevation effects.
Validation	None specific to snow	Comparison to SNOTEL (ground stations) and MODIS (satellite)
Future Scenarios	Delta Method; “2045”;”2085”; from 3 GCMs selected to span westwide temperature changes.	Delta Method: ”2055” from 5 GCMs spanning regional changes in temperature and precipitation
Analysis	Changes in long-term mean snowpack only	Means and variability, including wet, near normal and dry years.
Snow representation	Binary snow/no snow at 13 cm snow depth	Analyzed snow depth at two thresholds: 13mm of SWE (‘light snow’) and 0.5m depth (‘significant snow’)

Both Copeland et al (2010; hereafter, simply Copeland or the Copeland study) and McKelvey present analysis based on satellite remotely-sensed snow cover from the MODIS . For example, Copeland calculated the number of years with snowcover on May 15th as detected in the MODIS snowcover dataset, by calculating a snow disappearance date. They found that most (45 of 75) North American den sites were in areas that snow cover persisted with 6 or 7 out of 7 years on May 15th. We also provide a historical analysis of remotely sensed snow cover from MODIS. We also investigated the of number of years of snow persistence for our study areas, however, the new MODIS product has two advantages over that available at the time of their study, 1) improved snow detection (snow covered area, SCA), and 2) 17 years of MODIS data is now available vs the 7 available to Copeland and McKelvey. Furthermore, we investigated the relationships between snow cover persistence and both elevation and aspect (the compass direction of the slope face).

Both McKelvey and the present study investigate projections of snow cover using a distributed hydrologic model. McKelvey et al. (2011) (hereafter, simply McKelvey or the McKelvey study) focused their analysis on May 1st snow depth simulated by the Variable Infiltration Capacity hydrologic (VIC) hydrology model (1/16 degree, ~5km x 7 km), "flat" gridboxes, or cells, with no slope aspect dependence). The May 1st snow depth was then converted into a proxy for May 15th snow disappearance by applying a threshold of 13 cm – a procedure they refer to as "cross-walking". All subsequent calculations of theirs were done using the May 15th snow cover proxy. The VIC model runs were documented in Littell et al. (2011) and were based on meteorological inputs from Elsner et al. (2010). The present study uses the Distributed Hydrology Soil Vegetation (DHSVM) model, which was developed by the same group at the University of Washington for fine-scale simulations, and shares many model components with the VIC model. The primary output of DHSVM is snow water equivalent (SWE). We investigate several thresholds for converting SWE to "snow cover". Conversion of SWE to snow depth is done using empirically derived conversion factor relevant to late Spring.

To generate future climate scenarios, Littell (on which McKelvey results are based) used the "delta method" (described later in Section 5) for the projected changes in climate compared to present day. This study also uses the "delta method," applied in a similar manner. The McKelvey study used a range of temperature change to select GCMs representing the range or spread of future scenarios. As shown below in Section 5.10 and Figure 5.7, their chosen future scenarios reflect a range of precipitation in GLAC, but in ROMO, the three scenarios have similar precipitation changes. This project selected a larger number of future scenarios selected based on changes in both temperature and precipitation, to be consistent with recommended strategies for incorporation of uncertainties into the assessment of impacts and developing adaptation strategies (e.g. Fisichelli et al, 2016 a,b, see Section 5-8).

Analysis metrics, including the time frames of the projections differ somewhat between the two studies. The McKelvey study calculated a metric for a historic period (1915-2005 average) and two futures, 30-year averages around "2045" and" 2085." This study focused on a 30-year period [THAT IS 40 YEARS IF THE LAST YEAR MODELED WAS 2015] around mid-century, "2055" to focus on FWS' time horizons for the wolverine and due to time and computational constraints given the project budget. We also reproduce a single future scenario using one of the Littell (2011) "2080's scenarios for direct comparison. Calculations for a later period using the

CMIP5 climate models (e.g. ~2100) could easily be made, but were beyond the scope of this project. We provide analysis for two thresholds of snow amount, a “light” snow cover (13mm of snow water equivalent [SWE]), and significant, or “heavy” snow cover (equivalent to 0.5 m of snow depth). Because McKelvey only had access to May 1st snow depth simulation from Littell (2011), they chose to use a 13 cm snow depth on May1st [COMPARISONS TO MCKELVEY NEED TO BE 13CM ON THE 15TH, FOR DENS 1M ON APRIL 15TH IF I AM NOT MISTAKING ABOUT THE DATES] as a proxy for snow disappearance by May 15th. We instead chose to use a much lighter threshold of snow on May 15th itself. [NEED TO FOCUS DEN SITES ON THE DISAPPEARENCE FOR COMPARISON 13CM] Note that SWE is a measure of the water content in the snowpack; to estimate depth, a density of the snow must be assumed, i.e. an approximation of whether the snow is heavy or light. Our threshold of 13mm SWE was originally chosen to be comparable to McKelvey’s snow depth. Our assumptions are discussed further in Sec. 5.6.

An important difference between this study and prior work by Copeland et al. (2010) and McKelvey et al. (2011) is the spatial scale of results. McKelvey and Copeland both presented results on a regular 1/16 degree latitude-longitude grid, in which each cell, or gridbox is ~5-7 km on a side. These cells were assumed to be flat in the model-- that is they do not incorporate slope or aspect information in their surface energy balance. The result of this is north-facing slopes are treated identically to south-facing slopes. Our study uses the Distributed Hydrology Soil Vegetation Model (DHSVM) originally developed by Wigmosta et al. (1994)[1] for simulating the snowpack at 250m x 250m resolution that incorporates other physical drivers of snowpack (a complete energy balance at the surface, a 2-layer snow model, and a 2-layer vegetation canopy model) and allows analysis of snow at different slopes and aspects (slope directions). The VIC modeling included the option for elevational snow bands within the VIC grid (Jeremy Littell, pers. comm.) but the snow band information was not explicitly used. Therefore, sub-grid scale elevational effects are implicit and approximate in the VIC model whereas it is explicitly modeled at the 250m-scale in DHSVM. A visual comparison of the gridbox sizes is shown in Figure 2-3[THIS IS THE FIRST TIME THIS IS REFENCED THE ORDER NEEDS TO CHANGE], for further description of the terminology used to describe spatial resolution, see “resolution” in the Glossary. [YOU SEEMED TO HAVE MISED A CAVEAT THAT WE KNOW IS IMPORTANT AT HIGH ELEVATION WIND SWEPT AREAS. IF I AM REMEMBERING CORRECTLY, THE MODEL CANNOT MODEL WIND LOADING AND REMOVAL AND ITS AFFECTS ON LOCAL SCALE REDISTRIBUTION. I WOULD THINK A SIMPLE SENTENCE AND A CITATION WOULD WORK WORK].

It should be noted there are tradeoffs between our strategies and the methods of Copeland and McKelvey. The finer scale analysis presented in this report integrates slope and aspect with respect to snow accumulation and retention that are thought to be important for maintaining snow refugia for denning sites (see Fig 2 in McKelvey et al 2011). The disadvantage of this improvement in spatial resolution is we were only able to analyze two study areas due to time

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[1] The most up-to-date documentation of the DHSVM model, including changes to the model subsequent to the original reference, is available from the following website: http://www.hydro.washington.edu/Lettenmaier/Models/DHSVM/documentation.shtml)

and computational constraints. The Copeland and McKelvey projects analyzed a much larger domain, including most of the wolverine range in the continental US, but does not provide detailed analysis of any habitat area.

3 Observed Climate and Variability

Commented [GJM4]: In general, we think section 3 should be shortened if possible.

1-2 Intro paragraphs up front that give context on why the climate scenarios were chosen and why the specific years were used.

We can still discuss this. I marked the "background material" as such.

Key Points:

- Both study areas show upward trends in both temperature and freezing level.
- Surface Air Temperature and Atmospheric freezing level are related, with a stronger relationship in ROMO (that is, a greater change in freezing level for a given surface air temperature change)
- VARIBILITY IN WEATHER VERSUS CLIMATE CHANGE SCENARIOS
    - Representative years chosen for GLAC: 2011 (wet), 2005 (dry), 2009 (near normal).
    - Representative years chosen for ROMO: 2011 (wet), 2002 (dry), 2007 (near normal).

3.1 Introduction

This section presents a historical analysis of the winter and spring climate variability for the two study regions, GLAC and ROMO, in order to provide context for future changes. This section includes a discussion of trends in temperature and freezing level; historical variability in cool season (October – May) temperature and precipitation for the study areas, choice of representative years during the simulation period for cool/wet, warm/dry, and near normal conditions for the two areas; and a ranking of the representative years in a longer climate record. A complete description of regional climate is beyond the scope of this project, but may be found in e.g. McWethy et al (2010), Garfin et al (2014), Lukas et al (2014), Shafer et al (2014), and citations therein. [THINK YOU NEED TO EXPLAIN THE REPRESENTATIVE YEARS = VARIATION IN WEATHER- WHEREAS THE GCM ARE VARIATION IN CLIMATE. I DO NOT THINK ALL READERS WILL GET THIS.ITS BELOW, BUT HIT THEM EARLY AS IT IS A HUGE POINT.]

3.2 Background Material: Trends in Surface Temperature and Freezing Level in the Study Areas

Temperature strongly influences hydrologic processes such as snowpack accumulation, and timing of snowmelt. Here we present some background material on observed trends in surface air temperature and on the freezing level in the atmosphere, and how these two quantities are related.

Both the Glacier and Rocky Mountain areas show a trend of increasing surface air temperature in the winter season (October-May, Figure 3-1), consistent with trends that have been observed west-wide (Garfin et al 2014; Lukas et al 2014; Shafer et al 2014). While winter season temperatures vary inter-annually, linear regression of these data (not shown) indicates about a 1.4 ºC increase in temperature from 1948-2015 for an area around Glacier, and about a 1.2 ºC increase around Rocky Mountain National Park.

Atmospheric freezing level height (FLH) represents the altitude in the free atmosphere (that is, away from the surface and its immediate influence) where the temperature is 0 °C. Above this level, the temperature of the air is typically below freezing. Freezing in the free atmosphere is indicative of the level above which precipitation falls as snow rather than rain. Freezing level height can have a strong influence on freeze-thaw processes in high-elevation regions (Bradley et al 2009). As with winter season temperatures, freezing level varies over time (Figures 3-2, 3-3), but linear regression (not shown) indicates about a 160m increase in the freezing level for Glacier (Fig 3-2), and about a 170 m increase in the freezing level for Rocky Mountain (Fig 3-3).

Figure 3-4 illustrates a strong relationship between freezing levels and surface air temperature change for both regions in October-May with explained variance (R^2) close to 0.8. For GLAC (3-1, left), a 1ºC anomaly in temperature equates to about a 115 m increase in the freezing level, over the period. For ROMO, for 1ºC increase in temperature there has been about a 180 m increase in the freezing level (3-1, right). If these historical relationships hold in the future, the larger change in freezing level for the ROMO study area could indicate a greater sensitivity of snow covered area to rising temperatures.

3.3 Exploring Weather Variability through the Choice of Representative Years for Detailed Analysis

Commented [GJM5]: Describe weather (selection of years) vs. climate (GCMs) issue in more detail.

One of the primary study goals is to extend the analysis to include the effects of climate change on extreme years [BOUNDING WEATHER PATTERNS???] – both for years with high- and low- spring snowpack. This is in contrast to McKelvey et al (2011) who studied only the effect of climate change on the *long-term average* snowpack. Our historical snowpack analysis (Section 4) was performed for the entire period 2000-2013 and the hydrologic modeling (Section 5) for 1998-2013, and for the counterparts for these years under various climate change scenarios. To capture the weather variability within these periods we focus some of our analysis in Sections 4 and 5 on a representative wet, dry, and near normal year for each study area. Nonetheless, results from all years were computed.

Table 3-1: Historical Percentiles of precipitation and temperature for the representative dry, near normal, and wet years for GLAC and ROMO study areas.

	Year Type	Year	Oct. - May Precipitation Percentile	Oct. - May Temperature Percentile
GLAC	Dry	2005	6	83
GLAC	Near Normal	2009	45	42
GLAC	Wet	2011	98	6
ROMO	Dry	2002	4	45
ROMO	Near Normal	2007	56	69
ROMO	Wet	2011	96	36

To drive our choice of representative years, we investigated historical cold-season (October-May) temperature and precipitation anomalies and MODIS-based snow covered area for 2000-2013. Years were chosen within that range to represent a cool/wet year with high spring snowpack, a "near normal" year, and a "dry" year with low snowpack. Figure 3-5 shows scatterplots of the anomalous precipitation (as % of average) and temperature (degrees Celsius) for each year of the primary study period (2000-2013) for the two study areas. For both study areas, the 2011 winter stands out as a particularly large (cool/wet) anomaly.

The choice a dry year for GLAC points to 2005. Examination of the time series of Snow Covered Area (SCA) derived from the MODIS satellite product (Figure 3-6) corroborates this choice. For ROMO the hot/dry year 2012 with exceptionally low snow cover was first chosen. However modeling difficulties encountered in the model validation procedure described in section 5.4.2 led to the need to find an alternative "dry" year for ROMO. The scatter plot in Figure 3-5 indicates that 2004 or 2002 might both be good alternatives, and both of these years had adequate modeling success. Because 2002 had lower Spring snow cover (figure 3-6), and because it was a widely agreed upon drought year in Colorado, we chose to use 2002 as the representative "dry" year for ROMO.

For the choice of near-normal year, 2007 is indicated for ROMO, as that is closest to the center of the scatterplot in Figure 3-5. A number of choices would seem plausible for GLAC, however as no one year stands out as "most normal." To further guide our choices of representative years, we looked at the elevation profiles of SCA for the various years, and 2009 was chosen. We show the SCA as a function of elevation within the study areas (Figure 3-6cd) for the representative years. These plots indicate that the elevation profile of observed snow cover in our chosen near-normal years closely follow the median profile for 2000-2013.

3.4 The Study Period in the Longer Climate Record

Because the study period is 14 years long, the question arises as to how "extreme" the wet and dry years are in the longer climatological record. To address this we analyze how often the temperature and precipitation anomalies for the study years are likely to occur in the longer (1950-2013) climatological record by computing their percentiles. Percentiles were calculated by ranking the data and using the following formula: percentile = (rank – 0.5)/(total number of years). Note that the exact rankings and percentiles may differ based on the underlying dataset and interpolation methods used, as the study areas have relatively few observing stations. However, percentiles calculated from the PRISM dataset (not shown) yield qualitatively similar results to those found below.

The percentiles of October – May precipitation and temperature averaged over the study areas are shown for the representative wet, near normal and dry in Table 3-1 for both study areas. The percentiles are calculated based on the 63 total years in the 1951-2013 period of the Livneh (2014) dataset. For GLAC, October – May 2011 was at the 98th percentile of precipitation and the 6th percentile of temperature, while 2005 was at the 6th percentile of precipitation and 83rd percentile of temperature. For ROMO, 2011 was in the 96th percentile of October – May precipitation, but only the 36th percentile of temperature, and while anomalously cold was not extreme in temperature. 2002 was in the 4th percentile of precipitation, but only near the median in temperature.

For further reference, Tables 3-2 (GLAC) and 3-3 (ROMO) show the percentiles of precipitation and temperature for the entire study period, 2000-2013, as well as the percentiles for the April – June melt season. Even though the low precipitation was more extreme in 2002 than in 2012, the temperature was not. This is reflected in the MODIS spring snowcover (Figure 3-6[JUNE 1 IS NOT RELEVANT]), where 2002 was low, but not as nearly extreme as in 2012.

Table 3-2: Percentile of temperature and precipitation anomalies for GLAC study area based on the 1951-2013 period. Percentiles are shown for both the October – May cold season and for the April – June melt season.

GLAC	Percentile 1951-2013			
	Oct. - May Precipitation	Oct. - May Temperature	Apr. - June Precipitation	Apr. - June Temperature
2000	31	96	7	66
2001	2	37	47	58
2002	61	31	91	12
2003	33	87	13	69
2004	13	63	33	61
2005	6	83	80	47
2006	37	82	53	93
2007	21	72	6	75
2008	39	47	60	17
2009	45	42	12	34
2010	12	55	85	13
2011	98	6	87	4
2012	40	74	72	53
2013	60	66	56	29

Table 3-3: Percentile of temperature and precipitation anomalies for ROMO study area based on the 1951-2013 period. Percentiles are shown for both the October – May cold season and for the April – June melt season.

ROMO	Percentile 1951-2013			
	Oct. - May Precipitation	Oct. - May Temperature	Apr. - June Precipitation	Apr. - June Temperature
2000	45	98	40	98
2001	29	33	23	91
2002	4	45	2	96
2003	75	80	77	64
2004	21	91	75	77
2005	50	82	82	53
2006	28	74	4	94
2007	56	69	6	75
2008	80	12	45	13
2009	77	93	88	44
2010	48	13	87	37
2011	96	36	93	25
2012	10	94	7	99
2013	64	26	79	42

4 MODIS Observed Historic Snowpack Variability Analysis

Commented [GJM6]: Agree, it was used as validation for dhsvm, should come after. If you don't agree, you could break it up and keep the historical variability piece here and put the validation piece after chap 5

Commented [JJB7R6]: I don't mention validation here. We cover that briefly elsewhere and it distracts here.

Key points

- In GLAC, even in dry years, NE-facing slopes tend to hold more snow and melt later in the season. There is > 80% snow cover above ~2000 m elevation on May 1 during dry years, and > 95% snow cover above ~1200 m during wet years.[Copy this to Exec Summary] Snow conditions on June 1 during wet years resemble those for May 1 during near-normal years.[JUNE 1 NEEDS TO GO. MAY 15TH NEEDS TO BE 13CM, APRIL 15TH NEEDS TO BE BASED ON WOLVERIN DEN DEPTHS FROM PUBLISHED LITERATURE]
- In ROMO, NW-facing slopes tend to hold more snow even during dry years. In very dry years, snow cover peaks at intermediate elevations, suggesting that the high-altitude snowpack may be particularly vulnerable in this region under warm/dry conditions.[OR WIND REDISTRIBUTION IS HUGE, WHICH IT IS. A LOT OF THESE HIGH EVELATION WIND SWEPT AREAS DON'T HOLD SNOW IN THE MIDDLE OF THE WINTER AND THEY ARE PTARMIGAN COUNTRY]

4.1 Introduction

In this section we perform an analysis of the variability of snow cover in the historical period 2000-2016 using gridded snow cover data acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) on board the Terra satellite. The dataset and methodology of analysis is first described. The analysis for the GLAC and ROMO study areas are then presented in separate sections, repeating descriptions to make the material self-contained for the reader who may read about only one area. Each section consists of analysis of the following: a) total snow covered area (SCA), b) SCA fractional area as a function of eight compass directions of slope aspect (octants), and c) elevation dependence.

4.2 Dataset and Methods

4.2.1 Data sub-setting and re-projection

We downloaded selected MODIS/Terra daily snow cover data on a 500m grid from the recently released version 6 (MOD10A1.006) (Hall and Riggs, 2016). All data from geographic tiles h09v04 (ROMO) and h10v04 (GLAC) were downloaded for days between March 1 and July 1 for all years from 2000 to 2016.

The data are available in daily files, one for each tile, and georeferenced to an equal-area sinusoidal projection. Each tile covers 10° x 10° at the equator or approximately 1200 km by 1200 km, with a nominal pixel resolution of 500 m (actual resolution 463.313 m). To bring the data to the same grid as used in the hydrologic modeling necessitated re-projection of the data onto a Universal Transverse Mercator Grid. We used the MODIS Reprojection Tool (https://lpdaac.usgs.gov/tools/modis_reprojection_tool) to subset the daily tiles to the areas of interest and re-project the subsetted areas to UTM grids with a pixel resolution of 250 m using nearest-neighbor resampling. The ROMO study area perimeter falls at the corner of tile h09v04, and extends slightly beyond the tile boundaries at its southern tip. We excluded this extension of the study from our analysis. Parameters for the MODIS data reprojection are provided in Table S4-1.

4.2.2 Converting Normalized Difference Snow Index to Binary (yes/no) Snow Cover

To better align our analysis with that in Copeland and McKelvey's work we wanted to use a daily binary (yes/no) snow cover value. However, one main obstacle had to be overcome -- snow cover was characterized differently in the versions of the MODIS data that Copeland used and in the current version. The prior work by McKelvey and Copeland both used Collection 4 of the MODIS data which provided them with a binary snow cover classification for each pixel on each day (clouds permitting). Collection 4 data are only available for the years 2000-2007, necessitating the use of the more recent MODIS Collection 6 products for the present study. However, Collection 6 does not include a binary daily snow cover product. Instead, snow cover is identified using the Normalized Difference Snow Index (NDSI).

NDSI is reported as a ratio, with values ranging from 0.00 to 1.00 (scaled and reported as 0 to 100 in the data files). The NASA guidance on conversion was not definitive: "If a user wants to make a binary SCA [Snow Covered Area] from the C6 [Collection 6] product they can set their own NDSI threshold for snow using the NDSI_Snow_Cover or the NDSI data or a combination of those data." (NASA, 2016). In lieu of a prescription, we chose to follow the procedure used by NASA to produce the 8-day composite snowcover product; we applied a threshold of NDSI > 0.1 to the daily MODIS NDSI values to indicate the presence of snow in a pixel on a given day.

4.2.3 Snow disappearance date and snow cover on a given date

As in Copeland et al (2010), we calculate a snow disappearance date for each year at each pixel. We define the Snow Disappearance Date (SDD) as the first day after March 1 in which NDSI/100 was less or equal to 0.1 (Cite NASA). The SDD is denoted by the Day of Year value, in which January 1 is 1, February 1 is 32, March 1 is 60 (or 61 in leap years), etc. Once SDD was defined at each grid point for each year (resulting in 17 annual maps of SDD for the period of record), we were able to derive snow cover maps for any given date. For example, snow cover on May 1 was inferred by marking grid points as "snow-covered" if their SDD was equal or greater than 121 (or 122 for leap years). We repeated the process to infer snow cover maps for May 15 and June 1. This indirect method to infer snow cover allowed us to circumvent the reality of several missing data points due to cloud cover, and offered a conservative estimate of snow disappearance.

4.2.4 Snow cover by elevation and aspect

A 250-m digital elevation model (DEM) was created using bilinear interpolation from the National Elevation Dataset (NED)10-m DEM products (USGS, 2009). Using this we obtained grids for elevation and aspect octants in both study regions. We reclassified the elevation values into 200 m bins. The elevation bins range from 1000 to 3000 m in GLAC and 2600 to 4200 m in ROMO. Both the slope magnitude and the aspect of the slope (that is the compass direction that the slope faces) were analyzed using functionality in the open source Quantum GIS software. We reclassified the aspect grids into eight 45°-wide directional bins (hereafter, octants) centered on the points of the compass. In both types of analyses (elevation and aspect), we computed snow covered area (SCA) on May1, May15, and June1, in terms of the total area in square kilometers and also in terms of the percentage of snow covered area in several elevation bands and aspect octants.

4.3 MODIS analysis for GLAC

This section presents some summary statistics of snow cover, including total snow covered area, and number of years during the period of study with snow cover on a given date. MODIS snow cover data was analyzed for March1 – July1 for all years 2000-2016. For more in depth analysis including aspect and elevation-based analyses the report focuses on the representative years [OF [WEATHER VARIABILITY] defined in Section 3: 2011 ("wet"), 2009 ("near normal"), and 2005 ("dry").

4.3.1 Total Snow Covered Area

Total snow covered area was the primary metric that was analyzed in McKelvey et al (2011) and provides an overall summary of availability of snow. Figure 4-1 presents maps of May 15 snow cover for the GLAC study area and vicinity from MODIS. These maps clearly depict the regional character of the year-to-year variations in snowcover. Figure 4-2 shows the total snow covered area within the study area polygon, which is depicted in red on the previous figure. The year-to-year variations are shown for snowcover on three different dates during the melt season. The behavior in individual year varies considerably, including "wet" years such as 2011 with very persistent snow, years with strong melt in early May, such as 2012, or in late May (2009, 2001), and "dry" years (2004, 2005). The period of the modeling study in Section 5 ends in 2013 due to dataset limitations, but it is worth noting that the last two years of the MODIS record, 2015 and 2016 show low snowcover.[IT IS IMPORTANT THAT THE REASONS ARE CLEARLY STATED, THIS WILL LIKELY BE READ IN COURT AND WE DON'T WANT TO LEAVE IT TO FOLKS TO INTERPRIT] Both these years had near-normal precipitation, but had anomalously warm temperatures. These years would be good candidates for future analysis.

Commented [GJM8]: Why didn't you includes analysis for 2015 and 2016?
AJR: not in the Livneh dataset, say that the first place (here I think) – John also commented on this at beginning of 5, ~p 18

To summarize all 17 years of the record, Figure 4-3 presents maps of the number of years with snow cover on May 1, May 15, and June 1. These are similar to the analysis done by the Copeland and McKelvey studies. The primary difference is in the use of the newer MODIS products and the extension of the analysis from seven to seventeen years.

Figure 4-4 quantifies the maps in Figure 4-3, showing the area within the GLAC study area polygon with different numbers of years of snow cover. The three colored bars designate different days of the year. Because the study areas were chosen to be in the vicinity of tree line, it is no surprise that in the present climate there are large areas that see snow every year on May 1st. [NEED TO DEFINE WHY CHOSEN AT TREELINE VIA BIOLOGY MUCH EARLIER, SEEMS]

4.3.2 Aspect Dependence of Snowpack: Total Area

One of the primary goals of this study is to investigate topographic factors that influence the persistence of snow during the melt season. One such factor is the "slope aspect" or simply "aspect" – the compass direction that the slope faces. Figure 4-5 presents the dependence of total snow covered area (km^2) on aspect for each of the 17 years in the MODIS dataset, for May 1, May 15, and June 1. The shape of the curves for individual years is strongly determined by the topography of the region, with more land area located in the northwest and southeast octants. Upon closer inspection, other features become apparent. Comparing the SW and NE octants we see that there is greater year-to-year variability in the SW, indicating a greater sensitivity of SW-facing slopes to variations in the historical climate. Two representative years, 2011 and 2005, illustrate the progression of total snow covered area from May 1 to June 1 (Figure 4-6). In the dry year, 2005, snow cover declines faster on S, SW, and W slopes, as one would expect; this analysis quantifies the magnitude of this effect.

Commented [KED9]: If it is not standardized I am not sure what this means beyond, the the direction of the mountain chain. Maps show you were the snow is.

Commented [GJM10R9]: Steve agrees that non-normalized figures should be removed.

Commented [Office11R9]: Talk to Steve – we can take these out. We note that this is mainly the due to the land area itself.

4.3.3 Aspect Dependence of Snowpack: Fractional area

The total land area within each aspect octant varies due to the orientation of ridges and valleys in the study area. As a result, the analysis of total snow covered area is dominated by the topography itself. To focus on the *relative* importance of the snow processes related to aspect, we calculated the fraction of the total land area within each octant that is snow covered for each of the 17 years in the historical record, while in Figure 4-8 we focus on the representative wet and dry years. For example, in Figure 4-7[4-8], the asymmetric shape clearly shows that in GLAC, the NE directions ranging from E to N have much larger fractional area covered by snow. Even in dry years, over 60 % of the NE facing slopes are snow-covered on May 15th.

4.3.4 Elevation Dependence

Figure 4-9 shows the elevation dependence of MODIS snow cover for the wet, near-normal and dry years, with the median of all years as reference. The results are shown as a percentage of the total area within each 200-meter elevation band within the study area boundaries. [POINT, WEATHER RELATED VARIABLILTY IN WOLVERINE DEN RANGE FROM 90% LOST AT THE 1500M DEN VS. 0 - 40% LOSS IN THE HEART OF THE DEN ELEVATION RANGE.] [4-9 X AXIS IS LABELED WRONG. IT SHOULD BE AREA IN KM CORRECT]

Commented [GJM12]: We should put the dens on the y axis in fig 4-9. I also think fig 4-9 data should be changed; all jun 1 should be replaced with may 15. I can talk with you on phone about this.

Also, I think we need an additional bar chart that shows all years may 1 and may 15, snow covered area only for elevations where we have dens (~1500m-2300m). This would show historic SCA for the elevation bands that wolverines have used for denning.

Commented [GJM13R12]: June 1 is not relevant to wolverine denning. June 1 results should be removed and replaced with April 15 results. Final results should be April 15, May 1, and May 15.

Commented [Office14R12]: I was able to do most of this, but replacing June 1 with May 15 obscures some of the features we want to show – particularly since this is for MODIS, which responds to very light snow cover.

4.4 MODIS analysis for ROMO

MODIS snow cover data was analyzed for March1 – July 1 for the years 2000-2016. Data for all years was analyzed. We present here some summary statistics of snow cover, including total snow covered area, and number of years during the period of study with snow cover on a given date. For more in depth analysis including aspect and elevation-based analyses the report focuses on the representative years defined in Section 3: 2011 ("wet"), 2007 ("near normal"), and 2012 ("dry").[I THOUGHT 2002 WAS USED INSTEAD?????]

4.4.1 Total Snow Covered Area

Total snow covered area was the primary metric that was analyzed in McKelvey et al (2011) and provides an overall summary of availability of snow. Figure 4-10 presents maps of May 15 snow cover for the ROMO study area and vicinity from MODIS. These maps clearly depict the regional character of the year-to-year variations in snowcover. Figure 4-11 shows the total snow covered area within the study area polygon, which is depicted in red on the previous figure. The year-to-year variations are shown for snowcover on three different dates during the melt season. The behavior in individual year varies considerably, including "wet" years such as 2011 with very persistent snow, years with strong melt in early May, such as 2004, or in late May (2001, 2013), and "dry" years (2002, 2012).

To summarize all 17 years of the record, Figure 4-12 presents maps of the number of years with snow cover on May 1, May 15, and June 1. These are similar to the analysis done by Copeland and McKelvey studies. The primary difference is in the use of the newer MODIS products and the extension of the analysis from seven to seventeen years.

Figure 4-13 quantifies the maps shown in Figure 4-12, showing the area within the GLAC study area polygon with different numbers of years of snow cover. The three colored bars designate different days of the year. Because the study areas were chosen to be in the vicinity of tree line, it is no surprise that in the present climate there are large areas that see snow every year on May 1.

4.4.2 Slope Aspect Dependence of Snowpack: Total Area

One of the primary goals of this study is to investigate topographic factors the influence the persistence of snow during the melt season. One such factor is the "slope aspect" or simply "aspect" – the compass direction that the slope faces. Figure 4-14 presents the dependence of total snow covered area (km^2) on aspect for each of the 17 years in the MODIS dataset for May 1, May 15, and June 1. The shape of the curves for individual years is strongly determined by the topography of the region, with less land area available in the NW octant, and more in the NE. Compared to GLAC, the ROMO study area shows more year-to-year variation in the shape of the curves, likely indicating stronger meteorological controls on the directionality of the snowpack compared to the topographic control seen in GLAC. Comparing the SW and NE octants we see that there is greater year-to-year variability in the SW, indicating a greater sensitivity of SW-facing slopes to variations in the historical climate. Two representative years, 2002 and 2011, illustrate the progression of total snow covered area from May 1 to June 1 (Figure 4-15).The dry year, 2002, shows that snow cover starts out lower on May1 and declines faster on SE, S and SW slopes. The year 2012 is also shown and exhibits similar behavior to 2002 but with less overall magnitude.

4.4.3 Slope Aspect Dependence of Snowpack: Fractional Area

The total land area within each aspect octant varies due to the orientation of ridges and valleys in the study area. As a result, the analysis of total snow covered area is dominated by the topography itself. To focus on the *relative* importance of the snow processes related to aspect, Figure 4-16 presents an analysis of the fraction of the total land area within each directional "bin" that is snow covered. The asymmetric shape shows that the NW-facing slopes have larger fractional area covered by snow. With the exception of 2012, even in dry years over 60 % of the NW facing slopes are snow-covered on May 15th. Figure 4-17 indicates that for the dry year 2012, snow cover was retained preferentially on NW-facing slopes.

4.4.4 Elevation Dependence

Figure 4-18[JUNE 1 VS 15TH IN GLAC ALSO DOES NOT HAVE AREA BELOW THE FIRST FIGURE. IT NEEDS TO MIRROR FIGURE 4-9] shows the elevation dependence of MODIS snow cover for the wet, near-normal and dry years, with the median of all years as reference. The results are shown as a percentage of the total elevation within each 200-meter elevation band within the study area boundaries. The ROMO area shows that the dry year, 2002 (as well as the other very dry year during the period, 2012), was significantly different from the other two, with a fractional area declining with altitude above 3400m. This may indicate that the meteorology in this region interacts differently with the topography in extremely dry years than in wetter years. The high-altitude snowpack may be particularly vulnerable in this region if conditions like those in 2002 recur.

5 Future Snowpack Projections: DHSVM Modeling

Key Points - Methods

- We conducted this analyses to…………..
- The Distributed Hydrology Soil Vegetation (DHSVM) model was run for the historic period 1998-2013 and validated against available SNOTEL observing stations. The spatial patterns of snow were validated against MODIS satellite remotely sensed snow cover.
- Five scenarios of the future – a thirty year period[2055-30= 2025. YOU STOPED AT 2013 AND PROJECTED FORWARD THIS IF ~40 YEARS] centered on 2055 -- were selected from CMIP5 global climate model (GCM) projections based on a moderate (RCP 4.5) and high (RCP 8.5) emissions scenarios. These were chosen to represent a large fraction of the range of the CMIP5 ensemble projections in each study area in terms of precipitation and temperature changes. The scenarios differ somewhat between the two study areas to better represent the range of climate projections in each area.
- The selected GCM projections were downscaled using the "delta method" which applies change factors from the climate models to the historic temperature and precipitation that are used as inputs to the DHSVM model.
- Analysis is presented for light snow cover (Snow Water Equivalent > 13mm) for comparison with MODIS and McKelvey, and for 0.5 m of snow depth. [IT SEEMS THAT THE MAY 15 SHOULD ONLY BE COMPARED WITH MCKEVLEY WITH THE 13MM. 1M NEEDS TO BE COMPARED TO APRIL 15TH]
- To capture climate variability[THIS IS NOT CLIMATE RIGHT? THIS IS WEATHER VARIBILITY IN A CHANGING CLIMATE SO MAYBE TO UNDERSTAND HOW VARIABLIITY IN YEAR WEATHER PATTERNS…..], Wet, Near Normal, and Dry representative case study years are shown for the historical simulations and how each of these years plays out under these five future scenarios.

Key Points – GLAC study area.

- Snow Covered Area in GLAC and area with snow depth greater than 0.5 meters on May 15 declines on average in all scenarios on average and for almost all years
- On average, projections for the May 15 snowpack in the GLAC study area show a 12-42 percent decline in snow covered area, and a 15-68 percent decline in area with snow depth > 0.5 meters for the scenarios considered.
  - This resulted in X to X km2 in snow covered areas with > 0.5 meter snow cover
- All projections show declines in the number of years with significant snow. The areas with frequent (14-16 years) availability of significant snow become concentrated in smaller high elevation areas [GIVE THE RELEVANT STATS].
- For wet years, the high elevations of the study areas result in little loss of snowpack under most scenarios of change.
- For GLAC the Warm/Wet scenario shows the least change compared to the historic snow cover in terms of the area of significant (0.5 meter)[THIS NEEDS TO BE CHANGES TO 1M OR WHATEVER IT IS IN THE LITERATURE AND THEN CORRESPOND TO WHEN THEY ARE ABANDONING THE DENS APRIL 15TH I THOUGHT]

Commented [GJM15]: Replace this with stats for SCA projections for den elevation bands snowpack.[ISNT THIS THE MEAN OF THE GCMS FROM CHAPTER 2??] Under the Hot/Wet scenario, the May 1st significant snowpack diminishes to below the level of the historic June 1 snowpack[NOT RELEVANT TO WOLVERINES—DESCRIBE THE CHANGES ANOTEHR WAY].

Key Points – ROMO study area.

- Snow Covered Area in ROMO (13mm threshold on May 15) declines on average in all scenarios on average and for almost all years.
- On average, projections for the May 15 snowpack in the ROMO study area show a 12-52 percent decline in snow covered area, and a 7-64 percent decline in area with snow depth > 0.5 meters for the scenarios considered. [APRIL 15TH AND 1M CHECK WITH BETTY ABOUT THE ACTUAL DEPTH NEEDED]
    - This resulted in X to X km2 in snow covered areas with > 0.5 meter snow cover [1 ON APRIL 15TH]
- Snow Covered Area in ROMO (0.5 m threshold on May 15[13MM ON THE MAY 15TH FOR COMPARISON OR 1M ON APRIL 15TH) generally declines in wet years, but may increase in dry years in those scenarios with increased precipitation.
    - Scenarios[INDENTED THE BULLET TO SHOW THE PRECEEDING SENTENCES ARE FOLLOW UP THE DRY YEARS STATEMENT ABOVE] with increased precipitation may show increases in May 15 snowpack at the higher elevations in both study areas, but decreases in snowpack at lower elevations. This can lead to an increase in the area of > 0.5 meters of snow for dry years.
- ROMO exhibited more uncertainty in projections than GLAC
    - The beneficial effect of increased precipitation on snowpack is more prominent earlier in the Spring. In the Warm/Wet scenario, the area of significant snow on May1 increases on average, though it decreases on May 15.
    - For wet years, the high elevations of the study areas result in only modest loss of snow cover in the under all scenarios of change. However even in wet years, the area of significant snowpack can decline by almost 50% for the Hot/Dry climate change scenario.
    - Add stats on SCA for den elevation bands 2800-3000m.

5.1 Introduction

In this section we describe the hydrologic model along with various modeling assumptions, validation of the model, the choice of risk-spanning future climate scenarios, and present results of historical and projected snowpack for the two study areas.

To determine the projected effects of a changing climate on snowpack we ran a physically-based hydrology model. The physical basis of the model – using a full energy and water balance of the snowpack rather than a simple temperature-index model -- is critical to evaluate change in a non-stationary climate. While ambient temperature is a critical factor in whether precipitation falls as rain or snow, the subsequent evolution of the snowpack, and in particular the melt season, is driven primarily by the energy balance at the surface. The energy balance is the result of several processes, including solar and longwave radiation, sensible and latent heat fluxes, and heat flux into the ground, as well as storage of heat in the snowpack. Therefore, including a realistic energy balance helps to understand how the perturbations to climate will affect the snowpack.

5.2 Model Description

The Distributed Hydrology Soil Vegetation Model (DHSVM) provides a physically-based simulation of land surface hydrology, including snowpack. The physical processes include a full surface water and energy balance model, a 2-layer canopy model, a multi-layer soil model, a 2-layer snowpack model (Wigmosta et al. 1994). It has been used in many studies that have provided realistic hydrologic simulations in topographically complex areas (e.g. Livneh et al. 2015). The model has explicit treatment of topographic slope, and aspect (the compass direction that the slope faces).

The model was selected for developing snowpack projections because it can be run at a fine spatial scale (250 m x 250m pixels) yet is able to be run over extensive domains. There are both finer-scale snow models, for which it would have been impractical to simulate such a large domain, and coarser-scale models, such as the 1/16 degree grid of the VIC model that the McKelvey study used (see section 2.3). Coarser-scale models do not explicitly model the effects of slope and aspect, which is one of the primary goals of this study. Both DHSVM and VIC were primarily developed at the University of Washington, and are available as open-source community models. The two models share many components in common, including similar snow and canopy models. As such it supports the project goal of building on McKelvey study by modelling at a finer scale and treating slope and aspect explicitly.

The model was set up for both study domains on a 250m grid in Universal Transverse Mercator (UTM) coordinates within the modeling domain defined within the polygons shown in Section 2. Soil properties and vegetation type as well as a digital elevation model (DEM) were adapted to the model grid. A soil hydraulic routing network was also determined from the DEM, though in this project we do not investigate the runoff. The effect of slope and aspect on incoming solar radiation is implemented through a computation of the degree of shading for each 250-m pixel that was variable throughout the day and differed from month to month based on the solar angle in the sky and from the DEM. The model requires inputs of time-varying meteorological fields on sub-daily time scales. Snow water equivalent was output on May 1, May 15, and June 1 for every year of the simulation. As noted below, snow depth was estimated using a typical snowpack density for late Spring.

More details of the model will be included in the Section 5 Supplementary Material.

5.3 Meteorological Inputs

The DHSVM model inputs were derived in a multi-step process. First, values of daily minimum temperature, daily maximum temperature, and precipitation were extracted from the Livneh

(2015) dataset, which has a grid resolution of 1/16th degree in latitude and longitude. These daily values were disaggregated in time. Other forcing variables needed by the model, solar radiation, downwelling longwave radiation, specific humidity were derived from empirical relationships using the MTCLIM algorithms which were evaluated by Livneh et al. (2014) finding small overall biases. The Livneh et al (2015) data was then interpolated to the 250m DHSVM grid using an inverse-distance weighting algorithm along with assumed lapse rates (elevation dependence) in temperature and in precipitation. More details of the Livneh 2015 dataset will be included in the Section 5 Supplementary Material.

5.4 DHSVM Historical Validation

The goal of the model validation is to assess the overall magnitude, temporal, and spatial aspects of the modeled snowpack in the Spring and how these differ from observational estimates. Observational estimate of snow depth or snow water equivalent at the scales that we simulated are not available, leading to uncertainty about the "true" snowpack. For the overall magnitude and temporal aspects of the snow simulation, we compared the historical model simulation to point observations at the few available SNOTEL sites, focusing on the duration and melt-out date of the snowpack. The spatial aspect of bias was evaluated by comparing the model output to the observed spatial patterns of snow cover obtained from the MODIS analysis (see Section 4), qualitatively for GLAC and quantitatively for ROMO. When interpreting the projections, future model biases are typically assumed to be similar to historical biases. With this assumption, the calculation of, for example, percentage change is less sensitive to biases and uncertainties in the historical simulation.

5.4.1 Comparison to SNOTEL

The DHSVM historical simulation was compared against the snow data from nine SNOTEL sites in the ROMO study area that were in operation during the full time-period of interest, and the 3 SNOTEL sites in and adjacent to the GLAC study area (Table 5-1). Validation against SNOTEL snow data was performed by running the DHSVM model in "point" mode so that it simulated the conditions at the SNOTEL locations only. Because the SNOTEL stations are deliberately sited in clearings, the canopy was assumed to be open for the validation runs, while the actual 250m grid canopy values were used for the production runs. Two metrics were chosen: the meltout day of year (defined as the date when SWE fell to less than 1mm), and the duration of snow cover (total number of days during the water year (October-September) when SWE > 10cm). Figure 5-1a shows the modeled and observed meltout dates for the GLAC and ROMO SNOTEL sites, and Figure 5-1b shows the duration of snowpack. One does not expect exact reproduction of the snowpack at the SNOTEL sites, but rather a scatter about the 1-to-1 line, which is seen. The Copeland Lake, and to some extent the [SNOWTEL SITE CALLED MANY]Many Glacier SNOTEL sites are outliers, with the model retaining snowpack significantly longer than in observations. Both these sites are at relatively low elevations, and are quite sensitive to potential temperature biases in the input data. The Livneh (2015) dataset is known to have a cool bias relative to other datasets, which may influence these sites disproportionately.

Table 5-1 SNOTEL Sites at Study Areas. Maps with SNOTEL sites are shown in Figs 2-1 and 2-2.

	SNOTEL SITE NAME (Site Number, Abbreviation)
Glacier Study Area	Flattop Mountain (482, flat), Many Glacier (613, many), Pike Creek (693, pike)
Rocky Mountain Study Area (used for Validation)	Bear Lake (322, bear), Copeland Lake (412, cope), Joe Wright (551, joew), Lake Eldora (564, eldo), Lake Irene (565, iren), Niwot (663, niwo), Phantom Valley (688, phan), University Camp (838, univ), Willow Park (870, will)
Rocky Mountain Study Area (installed after 1997, not used)	Never Summer (1031), Wild Basin (1042), Hourglass Lake (1122), Long Draw Reservoir (1123), High Lonesome (1187), Sawtooth (1251)

The year-to-year variations of peak snowpack at the GLAC SNOTEL sites are well captured, as illustrated in Figure 5-2 that shows simulated and observed time series of SWE at these stations. Figure 5-3 shows selected SNOTEL sites in the ROMO area. As can be seen in Figure 5-2, the Copeland Lake site is less well simulated than other sites. We attribute this to being located at a lower elevation than other sites, and hence susceptible to small biases in temperature in the meteorological inputs. Other sites in ROMO are well simulated.

Based on this evaluation of DHSVM performance, the standard set of model parameters was adopted for the GLAC domain without modification.

The question arises of the independence of the SNOTEL data from the Livneh (2015) forcing data. The primary observing station data that were used for interpolation by Livneh (2015) did not include SNOTEL. However, a monthly adjustment factor was applied to the interpolated precipitation to reproduce the 1981-2000 climatology of PRISM. The temperature data in Livneh et al (2015) were entirely independent of SNOTEL data. Therefore, we expect that the errors revealed at the SNOTEL sites should be representative of errors at other, unobserved sites in the domain.

5.4.2 Comparison to MODIS Snow Cover

The spatial distribution of snow cover was assessed by comparison with MODIS data. Some care must be taken to compare observed NDSI, which indicated fractional snow cover, with modeled SWE, which does not account for fractional snow cover within a pixel. For this evaluation, a threshold to determine “snow covered ground” was chosen for both the MODIS NDSI (0.1) and for the DHSVM SWE. Figures 5-4 and 5-5 snow spatial overlays of the DHSVM simulated snow cover and the MODIS observed snow cover for the representative “dry” years in ROMO and GLAC. In terms of snow cover, dry years were more difficult to simulate than wet years, and the spatial agreement is good for these two examples.

However, initial attempts to model ROMO indicated biases in the spatial patterns of snow cover compared to MODIS. To overcome model errors at ROMO, an adjustment of two DHSVM snow parameters was conducted. The representative values of the physical quantities of these parameters can span a fairly large range, and hence an experiment was conducted to evaluate the appropriate settings of the model for ROMO based on minimizing differences between simulated and MODIS SCA for the historical period, as well as reducing biases with SNOTEL SWE.

The first parameter modified was the snow-surface roughness (SR), which affects the amount of turbulent heat fluxes that occur between the snow and the atmosphere, whereby a small number corresponds to a smoother snowpack that has less heat exchange with the overlying air, while the opposite is true for a large value. The second parameter was the liquid water capacity (LWC) that describes the volume of water that the snowpack can hold before water will leach out of the snowpack. This parameter is important, since it is common for snow to melt during the day and then for liquid water to refreeze at night.

Adjustments were made to SR and LWC within reasonable physical ranges and the DHSVM simulated SCA was compared with MODIS via a threat score. The threat score used, referred to as the Critical Success Index (CSI) by Zappa (2010), is defined as:

$$CSI = \frac{a}{a + b + c}$$

Where a indicates a snow-covered pixel in both the simulation and observed data, b indicates a snow-covered pixel in the simulation but a bare pixel in the observed ("false positive"), and c is a bare pixel for the simulation and a snow-covered pixel shown by the observed data ("false negative"). The objective was to maximize the threat score. Approximately ten unique parameter settings were tested. Additionally, for each parameter setting the mean bias in meltout day and duration of snow cover between DHSVM simulated and SNOTEL SWE was calculated with the objective being a minimization of the bias between the two (bias = simulated – observed). The final DHSVM settings for ROMO were identified by the parameter values that corresponded with a combination of a high threat score and a low bias. The table and figure showing the parameter settings and ensuing objective values are included in the supplementary material (Figure S5.X).

5.5 Determination of Snow Depth from DHSVM model output

DHSVM does not compute snow depth as a separate quantity, but instead returns snow water equivalent (SWE). To estimate the snow depth from SWE, a bulk density of the snowpack must be assumed. We adopt a density of 0.4 (or equivalently, at 2.5-to-1 ratio of snow depth to SWE, further discussion can be found in the Section 5 Supplementary Material) appropriate for the May snowpack in the study areas. Several lines of evidence point to the reasonableness of this assumption. First, SNOTEL stations where both depth and SWE are measured show similar ratios for the two study areas. Second, we investigated the ratio of density from the SNODAS (Snow Data Assimilation System) product from the NOAA National Operational Hydrologic Remote Sensing Center, which points to a very narrow range around 2.6-2.7 for the ratio. Finally, for comparison with the McKelvey et al (2011) work we compared the May 1 Snow Depth and SWE products from the Littell et al (2011) hydrologic model runs (obtained separately from https://cig.uw.edu/datasets/wus/). These all point to an approximate value consistent with a density between 0.35 and 0.4. The results of this study do not depend on a precise value for snow density. [ADD: SNOW DEPTH = (SWE X 2.5)]

5.6 Choice of thresholds for analysis

While the the McKelvey study analysis was for the presence or absence of snowcover, this modeling effort produces results in terms of SWE. This allows greater flexibility in evaluation of the depth of the snowpack, but presents a problem in comparison. To compare the model-generated SWE with both the McKelvey study results and our own MODIS historical snow cover analysis we investigated several threshold values of SWE: 1mm, 5mm, 13mm. For the purposes of this section we use the 13mm SWE threshold[WHY]. We also were concerned with analyzing the presence of "significant snow" which we defined as 0.5 m of snow depth, or 0.2 m of snow water equivalent using our assumed May snow density. The value of 0.5 m was arrived at by an analysis of the modeled snow depth at known wolverine denning sites in Glacier National Park (Table 5-2). With the exception of one site that had melted out by May 15th, the other sites all have snowpack between 0.4 and 1.4 m.[DEFINED EARLIER] [AGREED, BETTY NEEDS TO DEFINE THE DEPTH VIA THE LITERATURE]

Commented [GJM16]: This issue should be explained earlier as the 0.5 m results are reported throughout report and it is not explained why this value is used until pg. 32. Once April 15 results are available we should present these instead of May 15 depth. I expect the april 15 values will be 1m or more.

Table 5-2: Modeled Snow Depth on May 15 at reported den sites in the Glacier Study Area
(source: John Guinotte, FWS)

Den site	Date observed (month-yr)	Meltout Date (MODIS)	May 15 snow depth dhsvm (m)	May 01 snow depth dhsvm (m)	Notes
1	Apr-03	5/25/2003	1.036	1.068	Natal Den
2	May-03	5/25/2003	1.045	1.074	-Maternal Den
3	Apr-04	6/4/2004	0.407	0.653	-Natal Den
4	Apr-04	6/29/2004	0.539	0.753	-Maternal Den
5	May-04	6/29/2004	0.653	0.832	-Maternal Den
6	Mar-05	6/11/2005	0.531	0.797	-Maternal Den
7	Apr-05	6/11/2005	0.531	0.797	-Natal Den
8	May-05	6/11/2005	0.468	0.757	-Maternal Den
9	Mar-06	5/25/2006	1.435	1.434	-Unknown-materal or natal
10	Apr-06	5/14/2006	0	0.265	meltout occurred before may 15 Unknown-maternal or natal
11	Apr-06	6/7/2006	1.233	1.237	-Unknown-maternal or natal
12	May-06	5/31/2006	0.611	0.789	-Maternal Den
13	May-06	5/31/2006	0.611	0.789	Natal Den
14	May-07	6/4/2007	0.176	0.568	Natal Den

Commented [GJM17]: I will add two columns here for snow depth on May 1 and April 15. Need April 15 DHSVM results.

5.7 Delta Method for Future Scenarios

The advantages and disadvantages of the delta method have been discussed extensively in the literature (e.g. Sofaer et al, 2016, for a recent review). The primary advantages of this method are its long history of use, its simplicity, and its use of the historical observed weather as the baseline. The simplicity allowed for the study to be completed in a short time-frame, while still reaching our primary objectives of finer spatial scale and a more complete exploration of future climate scenarios. The use of the historical baseline allows us to explore how wet, near normal, and dry "representative years" would play out under the different climate futures. However, it is important to keep in mind that we are "parameterizing the future variability in terms of the historical variability." This treatment of daily variability also leads to the primary disadvantage of the delta method: the assumptions that the changes in extremes follow the changes in the means, and that the pattern of daily weather is simply shifted without changing the sequences of weather. This aspect is less of a concern for this study, as snow accumulation and ablation are cumulative processes, so that the daily sequences of storms is less critical to simulate than the monthly and seasonal totals. Another assumption of the delta method is that the large-scale changes in temperature and precipitation apply uniformly to the study area. Equivalently we assume that change factors in ambient (free-air) temperature and precipitation will not depend on the small scale spatial detail. Because we explicitly compute the surface energy balance, we are able to simulate surface temperature differences that depend on fine-scale terrain, mitigating to some extent this limitation of the delta method.

Following McKelvey (2011), we use the "delta method" to downscale the climate model data to the 250m modeling grid.

The steps in this method are as follows:

- Start with historical daily meteorological forcings (inputs to the DSHVM model) for the historical baseline period (1998-2013)
- Run DHSVM with the historical forcings to produce the simulated historical snow and hydrology.
- From climate model output, compute the change in 30-year average temperature for each calendar month over the time frame of interest. Do the same for the percent change in precipitation
- Apply these change factors to the historical daily meteorological inputs to DHSVM to generate future scenarios of meteorological inputs.
- Run DHSVM with these new inputs to generate the projected snow and hydrology.
- Compare the projected snow to the historic DHSVM model simulations to infer changes in snowpack.
- Repeat for a set of change factors from different climate models that adequately sample the uncertainty in climate projections.

The result of the delta method is a continuous-in-time simulation of the historical period (1998-2013), and an equal length simulation of how this sequence of years would play out in the future under five different scenarios of climate change. Figure 5-6 illustrates typical DHSVM model output using the delta method. Figure 5-6a shows a map of May 15, 2011 Snow Water Equivalent for the Glacier Study Area from the historical simulation, while Figure 5-6b shows a single projected future for what that year's SWE would look like under a particular scenario of climate change. The future scenario represents a year similar to 2011, that is, a relatively wet and cool year in the sequence, however the temperature and precipitation have been adjusted to be consistent with the 2041-2070 projected climate from the MIROC climate model [WHICH IS THE MOST EXTREME HOT/WET MODEL CORRECT?].

5.8 GCM Uncertainty and Scenario Planning Approach

As noted in Section 2, global climate models (GCMs) are our primary tools to examine the nature of climate change during the 21st century. There are currently about 20 modeling centers worldwide which provided output from their best model(s) to be considered in the Coupled Model Inter-comparison Project Phase-5 (CMIP5, Taylor et al., 2012) which informed the latest Intergovernmental Panel on Climate Change (IPCC) report (IPCC AR5). Here we quantify changes in temperature and precipitation for the two study areas for the 2014-2070 time frame. We find a large spread in the extent of warming and changes in precipitation, including both increases and decreases in precipitation, as shown in Figure 5-7. The McKelvey study chose GCMs based on the range of temperature change (see Sec 2.2, also shown in Figure 5-7). For temperature, much of this spread (or uncertainty) is a result of the difference between GCMs (e.g., their climate sensitivities), whereas for precipitation it is both the difference between GCMs and internal climate variability. Some difference also comes from the choice of future greenhouse gases (GHG) emission scenario. However, these differences among mid-21st century climate responses are limited compared to later in the century (see a discussion in Ray et al., 2010).

For more robust planning and climate adaptation, experts recommend incorporation of these uncertainties into the assessment of impacts and developing adaptation strategies. The scenario planning approach has been one method that has been recommend and promoted by different entities and experts (National Park Service, 2013; Rowland et al., 2014; Maier et al., 2016; Murphy et al. 2016; Star et al., 2016, Fisichelli et al, 2016 a,b). Therefore, we adopted a strategy of selecting multiple divergent future scenarios challenging to the system of interest, following that in Fisichelli et al (2016 a, b).

5.9 Climate Projections Evaluation and Scenarios Selection

We compiled output for temperature and precipitation projections for 34 CMIP5 GCMs from the Reclamation (2013; http://gdo-dcp.ucllnl.org/) archive of 1-degree Regridded GCM dataset for Representative Concentration Pathways (RCP) 4.5 and 8.5, which are respectively the moderate and high GHG emissions scenarios --- therefore, a total of 68 GCM projections described in Supplementary Material. These data were then analyzed to quantify broad-scale projections for the two study regions by 2055 (i.e. a mid-point centered on the 2041-2070 period) – primarily changes in the cold season (Oct-May) temperature and precipitation by 2055 relative to the 1986-2015 period. Figures 5-7 show these changes for Rocky Mountain and Glacier National Parks, respectively, which are bounded by rectangular latitude/longitude values. As mentioned earlier, we found a large range in temperature increases (1-4 ºC) and changes in precipitation (-5% to +20%) for these regions by 2055.[6/68= 91% INCREASING PRECIP IN GLAC, 15/68=78%

OF SCENARIOS INCREASING PRECIP IN ROMO, IT SEEMS TO ME THE CONTEXT OF THE CHAPTER 2 RANGE OF GCMS ARE NEVER REALLY BROUGHT INTO THE CONCLUSIONS ON HOW TO VIEW THE SCENARIOS] Table 5-3 shows GCM names, numbers and colors coded in later figures, and relative changes in temperature and precipitation. To incorporate the large range in climate projections, we worked with the ensemble of 68 CMIP5 temperature & precipitation projections, described by the red filled-circles in Figure 5-7, to select five future climate scenarios (black circles) that span the different parts of this projection space. Five GCMs representing these scenarios were identified for both RMNP and GNP. For each of these GCMs, we calculated changes in temperature and precipitation by 2055 for each month of the year, which we call the "monthly delta". These monthly deltas were used to perturb the hydrological models to simulate snow response in RMNP and GNP by 2055.

Table 5-3. The six future scenarios used (five for each area) with changes in temperature and precipitation relative to other scenarios (See also Fig 5-7 for an alternate visualization of these changes), and the GCM used as the basis for the deltas for this scenario. More details on the GCMs are in the Glossary.

Future Scenario Name and #	Scenario Change in GLAC relative to other scenarios	Scenario Change in ROMO relative to other scenarios	Code and color for GCM used for this scenario
Central (#1)	+~2.2 °C increase in temperature (close to the ensemble mean) and +~5% increase in precipitation	+~2.5 °C increase in temperature (close to the ensemble mean) and +~8% increase in precipitation	cnrm, red
GLAC: **Hot/ Very Wet** (#2)	relatively higher increase in temperature (+~3.2 C) and the highest increase in precipitation (+20%) for the GLAC scenarios	N/A	canesm, green
ROMO: **Hot/Dry** (#2)	N/A	relatively higher temperature increase (+~ 3.5 °C) and -~5% decrease in precipitation. This scenario results in the greatest change (reduction) in snow pack and snowcover.	hadgem, green
Hot/ Wet (#3)	the highest temperature increase of the GLAC scenarios (+~4.2 °C) and +~10% increase in precipitation	the highest temperature increase of the ROMO scenarios (+~3.7 °C) and the highest increase in precipitation (+~18%).	miroc, purple[CHECK THESE, MIROC IS ORANGE IN FIGS]
Warm/ Wet (#4)	relatively lower temperature increase (+~1 °C) and +~10% increase in precipitation	relatively lower temperature increase (+~1.3 °C) and +~7% increase in precipitation that appears to partially offset the impacts of the temperature increase. This scenario results in the least change in snow pack and snowcover.	giss, aqua
Warm/ Dry (#5)	relatively lower temperature increase (+~1.6 °C) and -~5% decrease in precipitation	relatively lower temperature increase (+~0.8 °C) and -~5% decrease in precipitation	fio, orange

5.10 Modeling Caveats

Some processes which may be of relevance not represented in the model include wind and avalanche re-distribution of snowpack. Snow depth is not explicitly modeled, and must be inferred (see below). The meteorological forcing does not take into account cold air pooling or how this may change in the future. Cold air pooling – the anomalously cold air that can collect in valley bottoms, particularly in Winter, could also act to prolong the duration of snow cover in those locations. While Curtis et al (2014) identify this as a potential process, they do not physically model cold air pooling, but merely include it in their present-day climatology as a simple "offset" from their unadjusted data. Nonetheless their work provides a complementary approach to the identification of potential snow refugia, though more work would need to be done to study the geographic and seasonal aspects for the study areas.

5.11 GLAC Study Area Results

5.11.1 SWE and Snow Covered Area for representative years

Figures 5-8 shows DHSVM model simulated snow water equivalent (SWE) on May 15 for the wet (2011) representative year. Maps of snow cover derived from SWE by applying a threshold of 13 mm are available in the Supplementary material[I WOULD REVERSE THIS THE SNOW COVER IS WHAT IS RELEVANT]. Results for thresholds of 1 mm and 5 mm of SWE were also investigated and show similar patterns. Snow covered area with a "light snow cover" threshold was computed primarily for comparison with both the MODIS results from Section 4, and with McKelvey. In Figure 5-8 [NEED TO MAKE AREAS BELOW THE 13MM THRESHOLD A DIFFERENT COLOR THAT IS EASLY SEEN SUCH AS BLACK], the historical simulation is shown along with three of the five future scenarios, chosen to represent the central scenario (cnrm), the greatest change in snowpack on average (Hot/Wet (miroc) scenario) and the least change (Warm/Wet (giss) scenario). The projected snow maps answer the question "what would the snowpack in a wet year like 2011 look like in the 2040's through 2070's under these scenarios of climate change."

Figures 5-9 and 5-10 show SWE [TOTALLY AGREE WITH JOHN OR WE NEED TO MAKE THE SWE TRESHOLD A VERY DISTINCE COLOR AND TEXT TO THE FIGURE LEGEND]for the Near Normal (2009) and Dry (2005) representative years. The historical simulation and future scenarios are as in Figure 5-8. Figure 5-11 summarizes the results for snow covered area in terms of the total snow covered area (km^2) within the study area polygon. The numerical values of snow covered area for all years in the simulation, as well as percent changes for these quantities are shown in Table 5-4. Table 5-4 indicates that the snowcovered area decreases for all scenarios. **On average, the GLAC study area exhibits a 12-42 percent decline in snow covered area on May 15 for the scenarios considered.**

- **Elevation at den graph should be incorporated here instead of an add on section later in the report.**
- Comparing the Wet and Dry representative years we see that dry years are more vulnerable to climate change in terms of percent loss of snow covered area.
- For the Wet year, the high elevations of the study area result in little loss of snowpack in the study areas under most scenarios of change.
- However, in Figures 5-10 and 5-11 we notice an anomaly – for the dry year, the Hot/Wet scenario does not have the greatest loss of snow covered area. The increase in precipitation in this scenario has somewhat compensated for the loss of snowpack due to warming.

GLAC Area (km^2)	Snow Covered Area (13mm SWE threshold) Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average	Median
1-May	historical	2552	2793	2655	2802	2890	2753	2533	2408	2636	2491	2883	2901	2524	2901	2758	2851	2708	2756
	Central (cnrm)	1768	2329	2030	2459	2816	2326	1812	1509	1959	1816	2742	2880	1886	2885	2179	2561	2247	2253
	Hot/Very Wet (canesm)	1394	1956	1707	1955	2595	1858	1303	1171	1510	1174	2436	2764	1293	2817	1723	2127	1862	1790
	Hot/Wet (miroc)	1573	1646	1604	1637	1518	2122	998	2275	1527	1517	2608	2037	1618	2481	1157	2165	1780	1627
	Warm/Wet (giss)	2197	2583	2388	2599	2856	2486	2191	2017	2312	2109	2842	2895	2170	2901	2485	2705	2484	2486
	Warm/Dry (fio)	2112	2440	2184	2586	2830	2555	2089	1776	2231	2070	2806	2891	2127	2900	2486	2659	2421	2463
15-May	historical	1452	2718	2433	2352	2873	2636	2287	2087	2373	1741	2807	2825	2393	2900	2557	2548	2436	2490
	Central (cnrm)	636	2114	1703	1780	2661	2068	1409	1104	1555	963	2367	2479	1664	2817	1763	1733	1801	1748
	Hot/Very Wet (canesm)	650	1835	1447	1419	2449	1652	1083	887	1255	657	2174	2218	1118	2697	1473	1584	1537	1460
	Hot/Wet (miroc)	1079	1440	977	1051	1230	1958	784	1451	1152	1026	2307	1677	1499	2305	879	1760	1411	1335
	Warm/Wet (giss)	1079	2483	2098	2062	2800	2332	1963	1667	1981	1299	2638	2672	2034	2882	2203	2247	2152	2151
	Warm/Dry (fio)	883	2274	1913	1910	2712	2372	1722	1397	1851	1138	2515	2600	1918	2864	2125	1943	2009	1931
1-Jun	historical	863	2360	1759	1114	2599	1932	1864	1375	1446	1061	1923	2205	1907	2863	2171	2035	1842	1915
	Central (cnrm)	250	1512	948	628	2049	1099	897	560	663	417	1005	1397	1025	2600	1281	1114	1090	1015
	Hot/Very Wet (canesm)	328	1393	909	590	1923	966	742	514	689	347	1172	1414	794	2455	1118	1134	1030	937
	Hot/Wet (miroc)	496	813	359	282	682	1109	417	552	267	511	1008	682	831	1862	527	786	699	617
	Warm/Wet (giss)	613	2046	1392	883	2401	1507	1473	1046	1063	759	1574	1893	1580	2789	1763	1747	1533	1541
	Warm/Dry (fio)	401	1723	1137	623	2217	1410	1196	735	810	527	1222	1606	1178	2691	1611	1291	1274	1209

% change	Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average	Median
1-May	Central (cnrm)	-31	-17	-24	-12	-3	-16	-28	-37	-26	-27	-5	-1	-25	-1	-21	-10	-17	-18
	Hot/Very Wet (canesm)	-45	-30	-36	-30	-10	-33	-49	-51	-43	-53	-15	-5	-49	-3	-38	-25	-31	-35
	Hot/Wet (miroc)	-38	-41	-40	-42	-47	-23	-61	-6	-42	-39	-10	-30	-36	-15	-58	-24	-34	-41
	Warm/Wet (giss)	-14	-8	-10	-7	-1	-10	-13	-16	-12	-15	-1	0	-14	0	-10	-5	-8	-10
	Warm/Dry (fio)	-17	-13	-18	-8	-2	-7	-18	-26	-15	-17	-3	0	-16	0	-10	-7	-11	-11
15-May	Central (cnrm)	-56	-22	-30	-24	-7	-22	-38	-47	-34	-45	-16	-12	-30	-3	-31	-32	-26	-30
	Hot/Very Wet (canesm)	-55	-32	-41	-40	-15	-37	-53	-58	-47	-62	-23	-22	-53	-7	-42	-38	-37	-41
	Hot/Wet (miroc)	-26	-47	-60	-55	-57	-26	-66	-30	-51	-41	-18	-41	-37	-21	-66	-31	-42	-46
	Warm/Wet (giss)	-26	-9	-14	-12	-3	-12	-14	-20	-17	-25	-6	-5	-15	-1	-14	-12	-12	-14
	Warm/Dry (fio)	-39	-16	-21	-19	-6	-10	-25	-33	-22	-35	-10	-8	-20	-1	-17	-24	-18	-22
1-Jun	Central (cnrm)	-71	-36	-46	-44	-21	-43	-52	-59	-54	-61	-48	-37	-46	-9	-41	-45	-41	-47
	Hot/Very Wet (canesm)	-62	-41	-48	-47	-26	-50	-60	-63	-52	-67	-39	-36	-58	-14	-49	-44	-44	-51
	Hot/Wet (miroc)	-42	-66	-80	-75	-74	-43	-78	-60	-82	-52	-48	-69	-56	-35	-76	-61	-62	-68
	Warm/Wet (giss)	-29	-13	-21	-21	-8	-22	-21	-24	-27	-28	-18	-14	-17	-3	-19	-14	-17	-20
	Warm/Dry (fio)	-54	-27	-35	-44	-15	-27	-36	-47	-44	-50	-36	-27	-38	-6	-26	-37	-31	-37

Table 5-4: GLAC Snow Covered Area (13mm SWE threshold) Top: Area (km^2) in historical and five future scenarios. Bottom: percent change in future simulations compared to historical. Average and Median values also shown.

APPENDIX????[YES I AGREE THIS IS AN APPENDIX]

5.11.2 Area and Number of years with 0.5 m Snow Depth

Because of interest in wolverine denning sites, we analyze snow depth > 0.5 m, which we will also refer to as "significant snow" to contrast with the emphasis on light snow in McKelvey et al (2011) and in the previous section. Figure 5-12 shows the area with snow depth > 0.5 m on May 15[Mckelvey comparison to 13MM- THEN DO APRIL 15 AND 1M OR WHATEVER BETTY GIVES US HERE] within the study area for the dry, near normal, and wet years. Because of the higher threshold for snow, the effects are somewhat larger than for the light snow threshold. This is particularly evident in the dry year, which has a 50% decline on May 15 for four of the future scenarios. The numerical values of snow covered area at the > 0.5 m threshold are shown in Table 5-5 for all years, as well as percent changes for these quantities. **On average, the GLAC study area exhibits a 15 – 68 percent decline in the area of snow depth > 0.5 meters for the scenarios considered.**
Figure 5-22 here, plus text to accompany the results from this figure. Also include the X to X km^2 area that correspond to the 15-68 declines.

Figure 5-13 shows a map of the number of years (out of 16 possible) where each model pixel had at least 0.5 m of snow depth on May 15. This number-of-years statistic is analogous to that used by the Copeland study, except that there are more years of data, and these maps use a much higher threshold of snow. The projections show declines in the number of years with significant snow. The areas with frequent (14-16 years) availability of significant snow become concentrated in smaller high elevation areas.

The effects of climate change on snow melt have been presented as analogous to a "time shifting" of the melt season earlier in the year. For example, McKelvey used the May 31 vs. May 15 snow covered area as a proxy for a 2-week shift in the melt season. Figure 5-14 contrasts the evolution of the snowpack from May 1 to June 1[JUNE 1 IS NOT RELEVANT AND LATE SEASON MELT COULD REALLY BIAS THIS RESULT] in the historical simulations (Top Row) with the Warm/Wet scenario (Middle Row) and Hot/Wet (Bottom Row) scenarios. We see that the Warm/Wet scenario, shows the least change compared to the historic snow cover in terms of the availability of significant snow. In contrast, under the Hot/Wet scenario, the May 1st significant snowpack has been diminished below the level of the historic June 1 snowpack – greater than a month shift. [CUT]

Snow Covered Area (0.5 m depth threshold)

Area (km^2)	Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average	Median
1-May	historical	1594	2545	2204	2326	2844	2392	2032	1800	2124	1571	2613	2731	1692	2901	2453	2625	2278	2359
	Central (cnrm)	770	1826	1477	1912	2530	1766	1137	912	1283	951	2160	2383	965	2847	1630	1893	1653	1698
	Hot/Very Wet (canesm)	733	1587	1234	1399	2283	1336	826	732	1075	578	1992	2070	677	2721	1316	1650	1388	1326
	Hot/Wet (miroc)	474	526	633	425	458	1538	395	614	364	541	1321	1236	332	2029	436	1018	771	533
	Warm/Wet (giss)	1154	2242	1810	2012	2681	1968	1590	1400	1660	1112	2389	2525	1360	2890	2017	2328	1946	1990
	Warm/Dry (fio)	974	1938	1594	1877	2586	2054	1368	1058	1471	969	2169	2418	897	2873	1944	2046	1765	1907
15-May	historical	550	2496	1937	1417	2749	2201	1673	1308	1805	804	2317	2537	1647	2881	2135	2035	1906	1986
	Central (cnrm)	140	1731	1161	1087	2329	1453	792	566	961	328	1585	1957	911	2692	1284	1139	1252	1150
	Hot/Very Wet (canesm)	247	1537	1048	835	2128	1176	648	509	900	274	1632	1797	662	2538	1087	1155	1136	1068
	Hot/Wet (miroc)	302	508	346	217	439	1447	203	531	290	302	1053	878	565	1733	352	634	612	473
	Warm/Wet (giss)	380	2199	1546	1166	2560	1782	1287	995	1362	567	2051	2286	1355	2825	1693	1745	1612	1620
	Warm/Dry (fio)	199	1873	1301	880	2438	1781	986	659	1106	328	1692	2096	879	2765	1559	1208	1360	1255
1-Jun	historical	337	1903	1089	428	2156	1192	1199	723	845	486	1140	1590	1144	2782	1625	1534	1261	1168
	Central (cnrm)	52	1052	494	202	1473	563	435	227	310	145	462	810	514	2353	827	738	666	504
	Hot/Very Wet (canesm)	113	1024	572	238	1476	585	437	262	398	145	667	956	429	2254	781	847	699	579
	Hot/Wet (miroc)	90	220	100	36	194	542	104	103	43	158	284	194	185	1319	194	250	251	190
	Warm/Wet (giss)	221	1545	817	321	1895	870	928	534	589	346	859	1262	973	2646	1246	1298	1022	899
	Warm/Dry (fio)	97	1139	567	164	1598	724	602	294	377	157	552	876	522	2457	1049	817	749	584

% change	Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average	Median
1-May	Central (cnrm)	-52	-28	-33	-18	-11	-26	-44	-49	-40	-39	-17	-13	-43	-2	-34	-28	-27	-28
	Hot/Very Wet (canesm)	-54	-38	-44	-40	-20	-44	-59	-59	-49	-63	-24	-24	-60	-6	-46	-37	-39	-44
	Hot/Wet (miroc)	-70	-79	-71	-82	-84	-36	-81	-66	-83	-66	-49	-55	-80	-30	-82	-61	-66	-77
	Warm/Wet (giss)	-28	-12	-18	-13	-6	-18	-22	-22	-22	-29	-9	-8	-20	0	-18	-11	-15	-16
	Warm/Dry (fio)	-39	-24	-28	-19	-9	-14	-33	-41	-31	-38	-17	-11	-47	-1	-21	-22	-23	-19
15-May	Central (cnrm)	-75	-31	-40	-29	-15	-34	-53	-57	-47	-59	-32	-23	-45	-7	-40	-44	-34	-42
	Hot/Very Wet (canesm)	-55	-38	-46	-41	-23	-47	-61	-61	-50	-66	-30	-29	-60	-12	-49	-43	-40	-46
	Hot/Wet (miroc)	-45	-80	-82	-85	-84	-34	-88	-59	-84	-62	-55	-65	-66	-40	-84	-69	-68	-76
	Warm/Wet (giss)	-31	-12	-20	-18	-7	-19	-23	-24	-25	-29	-11	-10	-18	-2	-21	-14	-15	-18
	Warm/Dry (fio)	-64	-25	-33	-37	-11	-19	-41	-50	-39	-59	-27	-17	-47	-4	-27	-41	-29	-37
1-Jun	Central (cnrm)	-85	-45	-55	-53	-32	-53	-64	-69	-63	-70	-59	-49	-55	-15	-49	-52	-47	-57
	Hot/Very Wet (canesm)	-66	-46	-47	-44	-32	-51	-64	-64	-53	-70	-42	-40	-63	-19	-52	-45	-45	-50
	Hot/Wet (miroc)	-73	-88	-91	-92	-91	-55	-91	-86	-95	-67	-75	-88	-84	-53	-88	-84	-80	-84
	Warm/Wet (giss)	-34	-19	-25	-25	-12	-27	-23	-26	-30	-29	-25	-21	-15	-5	-23	-15	-19	-23
	Warm/Dry (fio)	-71	-40	-48	-62	-26	-39	-50	-59	-55	-68	-52	-45	-54	-12	-35	-47	-41	-50

Table 5-5: GLAC Snow Covered Area (0.5 m snow depth threshold) Top: Area (km^2) in historical and five future scenarios. Bottom: percent change in future simulations compared to historical. Average and Median values also shown.

5.12 ROMO Study Area

On average, the ROMO study area exhibits a 7 – 64 percent decline in the area of snow depth > 0.5 meters on May 15 for the scenarios considered. Note that the Warm/Wet scenario projects a slight increase in the area of significant snowpack on May 1.

5.12.1 SWE and Snow Covered Area for representative years

Figure 5-15 shows DHSVM model simulated SWE on May 15th for the wet representative year (2011). The historical simulation is shown along with three of the five future scenarios, chosen to represent the central scenario (cnrm), the greatest change in snowpack on average (Hot/Dry (hadgem2) scenario) and the least change (Warm/Wet (giss) scenario). The future scenarios answer the question "what would the snowpack in a wet year (like 2011) look like in the 2040's through 2070's under these scenarios of climate change." Note that the "greatest snowpack change" scenario is different for ROMO than for GLAC. We have included Hot/Dry in the choice of scenarios for ROMO because a significant number of climate models project drying conditions in ROMO, whereas in GLAC, the vast majority of climate models predict a wetter future.

Figures 5-16 and 5-17 shows SWE for the "Near Normal" (2009) and "Dry" (2002) year. One can see that in the dry year, the snow cover is already very sparse even in the historical simulation.

Figure 5-18 summarizes the results in terms of the total snow covered area (km^2) within the study area polygon. In this case, the threshold used is 13mm of SWE, representing a light snow cover, and comparable to the results in McKelvey. Comparing the Wet and Dry years we see, as with GLAC, that dry years are more vulnerable to climate change in terms of percentage of area lost. For the Wet year, the high elevations of the study area result in little loss of snowpack in the study areas under most scenarios of change. The numerical values of snow covered area for all years, as well as percent changes for these quantities are shown in Table 5-7. **On average, the ROMO study area exhibits a 12-52 percent decline in snow covered area on May 15 for the scenarios considered.**

ROMO	Snow Covered Area sq-km [13mm SWE threshold]																		
	Scenario	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average	Median
1-May	historical	1567	1514	1574	1523	1245	1594	1248	1580	1573	1556	1595	1578	1439	1593	779	1594	1472	1570
	Central [ccsm]	1380	1216	1424	1112	786	1571	655	1470	1376	1195	1593	1396	1091	1553	379	1547	1234	1378
	Hot/Dry [hadgem2]	1127	971	1079	844	418	1498	429	1114	1188	1081	1587	1267	763	1507	185	1462	1033	1097
	Hot/Very Wet [miroc]	963	569	1045	773	501	1425	293	1280	1215	701	1582	1003	837	1444	112	1382	945	983
	Warm/Wet [giss]	1498	1429	1510	1373	944	1589	964	1522	1528	1461	1595	1547	1335	1586	583	1587	1378	1504
	Warm/Dry [fio]	1462	1392	1546	1363	981	1584	828	1519	1518	1433	1595	1533	1234	1584	481	1580	1351	1490
15-May	historical	1427	1467	1146	1064	989	1592	831	1519	1490	1421	1593	1449	1372	1587	588	1566	1319	1438
	Central [ccsm]	1012	1076	728	495	526	1546	340	1206	982	872	1563	953	951	1485	245	1366	959	967
	Hot/Dry [hadgem2]	530	688	250	221	213	1395	119	671	650	569	1410	470	562	1320	80	846	625	565
	Hot/Very Wet [miroc]	637	483	457	385	327	1346	141	948	858	491	1510	615	742	1395	78	1193	723	626
	Warm/Wet [giss]	1236	1315	877	814	693	1583	554	1346	1312	1242	1585	1246	1228	1559	396	1515	1156	1244
	Warm/Dry [fio]	1227	1311	928	795	695	1573	504	1361	1302	1200	1588	1279	1141	1556	344	1505	1142	1253

	Snow Covered Area % change [13mm SWE threshold]																		
	Scenario	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average	Median
1-May	Central [ccsm]	-12	-20	-10	-27	-37	-1	-48	-7	-13	-23	0	-12	-24	-2	-51	-3	-16	-12
	Hot/Dry [hadgem2]	-28	-36	-31	-45	-66	-6	-66	-30	-24	-30	-1	-20	-47	-5	-76	-8	-30	-30
	Hot/Very Wet [miroc]	-39	-62	-34	-49	-60	-11	-77	-19	-23	-55	-1	-36	-42	-9	-86	-13	-36	-37
	Warm/Wet [giss]	-4	-6	-4	-10	-24	0	-23	-4	-3	-6	0	-2	-7	0	-25	0	-6	-4
	Warm/Dry [fio]	-7	-8	-2	-11	-21	-1	-34	-4	-3	-8	0	-3	-14	-1	-38	-1	-8	-5
15-May	Central [ccsm]	-29	-27	-37	-53	-47	-3	-59	-21	-34	-39	-2	-34	-31	-6	-58	-13	-27	-33
	Hot/Dry [hadgem2]	-63	-53	-78	-79	-78	-12	-86	-56	-56	-60	-12	-68	-59	-17	-86	-46	-53	-61
	Hot/Very Wet [miroc]	-55	-67	-60	-64	-67	-15	-83	-38	-42	-65	-5	-58	-46	-15	-87	-24	-45	-56
	Warm/Wet [giss]	-13	-10	-23	-23	-30	-1	-33	-11	-12	-13	-1	-14	-11	-2	-33	-3	-12	-13
	Warm/Dry [fio]	-14	-11	-19	-29	-30	-1	-39	-10	-13	-16	0	-12	-17	-2	-41	-4	-13	-13

Table 5-6: ROMO Snow Covered Area (13 mm SWE threshold) Top: Area (km^2) in historical and five future scenarios. Bottom: percent change in future simulations compared to historical. Average and Median values also shown.

5.12.2 Area and Number of years with 0.5 m Snow Depth

Because of interest in wolverine denning sites, we analyze snow depth > 0.5 m, which we will refer to here as "significant snow." Figure 5-19 shows the area with snow depth > 0.5 m within the study area. Because of the more stringent threshold for snow, the effects are somewhat larger than for the light snow cover. The numerical values of snow covered area at the > 0.5 m threshold are shown in Table 5-7 for all years, as well as percent changes for these quantities. In this table, we note that dry years such as 2002 see increases in snow covered area for the Hot/Very Wet and Warm/Wet scenarios. As in GLAC, dry years are somewhat buffered against change, and in fact can see increases in high-altitude "significant" snow for scenarios with increased precipitation. This is a result of the elevational dependence of snowpack change that will be discussed in the next sub-section. **On average, the ROMO study area exhibits a 7 – 64 percent decline in the area of snow depth > 0.5 meters on May 15 for the scenarios considered. Note that the Warm/Wet scenario projects a slight increase in the area of significant snowpack on May 1. [WARM/WET IS WHAT THE AVERAGE OF THE GCM'S RIGHT, SAME POINT BEFORE ON CHAPTER 2 CONTEXT NOT BEING BROUGHT BACK INTO THE DISCUSSION]**

Figure 5-20 [THIS SHOUD BE 13MM NOT 0.5M IF COMPARING TO COPELAND] shows a map of the number of years (out of 16 possible) where each model pixel had at least 0.5 m of snow depth on May 15th. This summary statistic is analogous to that used by the Copeland study, except that there are more years of data, and these maps use a much higher threshold of snow. The projections show declines in the number of years with significant snow. The areas with frequent (14-16 years) availability of significant snow become concentrated in smaller high elevation areas. The Hot/Dry "greatest change" scenario, illustrates that the combination of drying and warming leads to very large declines in the persistence of snow.

The effects of climate change on snow melt have been presented as analogous to a "time shifting" of the melt season earlier in the year. For example, McKelvey (2011) used the May 31st vs. May 15th snow covered area as a proxy for a 2-week shift in the melt season. Figure 5-21 contrasts the evolution of the snowpack from May 1 to June 1 in the historical simulations (Top Row) with the Warm/Wet scenario (giss, Middle Row) and Hot/Dry (hadgem, Bottom Row) scenarios [Graphics being re-done]. [JUNE 1 IS NOT BIOLOGICALY RELVANT TO WOLVERING DENSE, IT NEEDS TO BE REMOVED FROM THE REPORT]

5.13 Elevation Dependence of Snowpack Change in the DHSVM model

Snowpack accumulation and melt depends critically on temperature and hence on elevation. In the Warm/Dry and Hot/Dry scenarios, both the precipitation decrease and the warming act to reduce Spring snowpack. For the scenarios with warming and increased precipitation there are two countervailing forces that play out along an elevational gradient. A warmer, wetter future is one in which the freezing level and snow line tends to be higher, but with the potential for greater snowpack accumulation during the cold season at high elevations. The warming also tends to lead to an earlier snowmelt, so that the increased high-elevation snowpack is more evident early in the Springtime than later

Figures 5-22 shows the percent change in May 1st snow covered area (SCA; 0.5 meters depth) for GLAC, computed for 200 m elevation bands. The elevation of observed den sites is noted by triangles, with den sites ranging from approximately 1500m to 2300 m. There is little change in SCA for 4 of the 5 scenarios above 2200m.[COPY THIS TO EXEC SUMMARY] As in a mirror image there is greater than 95 % loss of SCA below 1400m for 4 of the 5 scenarios. Between these two elevations – and in the regions where most observations of dens have been noted – the snowpack change is very sensitive to elevation and to the particular future climate scenario.[MOST OF THE DENS ARE AT 1800 TO 2000, BELOW THAT BAND LARGE LOSSES PREDICTED, ABOVE THAT ELEVATION BAND MINIMAL LOSSES PREDICTED ACCEPT IN ARE MAXIMUM WARMING SCENARIO] Figure 5-23 shows the elevation dependence of the May 1st snowpack measured in terms of snow water equivalent (SWE). Viewing snowpack in terms of SWE illustrates more clearly that the Hot/Very Wet future scenario has a greater snowpack at high elevations despite completely losing its snowpack at 100m elevation. Figure 5-23 also illustrates that SWE can have modest declines without affecting the area with significant snow depth. The implications is that wet, cold climate of the GLAC study area can act as a "buffer" to change in the area of 0.5 meter deep snow on May 1st, at least at high elevations.[COPY TO EXEC SUMMARY]

Figure 5-24 shown the May 1st SCA (0.5 meter depth) for ROMO. The high elevation areas show a loss of SCA for four of the five future scenarios, which an increase only in the Warm/Wet (giss) scenario. The climate of ROMO is, on average drier than that of GLAC, and the regions of the model simulations that have significant snow in most years is restricted to the two smaller areas within the domain (Figure 5-21). As a result the climate does not act to buffer change in the area of significant snow on May 1st.

This phenomenon of elevation-dependent snowpack change in the Western US is well supported in the literature. Regonda et al. (2005) found little historical change in snowpack in the Western United States above approximately 2500m elevation despite observed warming trends. .[COPY TO EXEC SUMMARY] Christensen and Lettenmaier (2007) considered VIC hydrology model projections and reported as strong elevation dependence for snowpack loss in the Colorado River basin below 2500 m elevation (their data was visualized in Ray et al. 2008). Two recent studies are of special interest because they focus on areas near those considered here. Sospendra-Alfonso et al (2015), on an area near the GLAC study area, find that historically, temperature has been a larger driver of April 1st snowpack only below about 1560 m elevation, with precipitation the main driver of variability above that elevation. Scalzitti et al. (2016) investigated a single climate change scenario using a high-resolution weather model and found that the critical elevation below which temperature dominates snowpack rises by about 250m in the Colorado Rockies, and rises by about 191 m in the Northern Rockies hear the GLAC study area. While it is difficult to these results directly to the present study due to differences in methodology, the qualitative picture remains – projected warming has a larger effect at lower elevations whereas projected precipitation changes may dominate the Springtime snowpack in the high country. [COPY TO EXEC SUMMARY]

ROMO **Snow Covered Area sq-km (0.5 meter snow depth threshold)**

	Scenario	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average	Median
1-May	historical	468	249	734	180	26	1578	90	422	418	746	1334	594	70	1366	22	381	542	420
	Central [ccsm]	421	185	607	95	38	1470	102	375	208	338	1199	451	55	1293	16	402	457	386
	Hot/Dry [hadgem2]	166	57	232	64	10	1245	33	137	278	314	984	231	14	1096	2	125	312	152
	Hot/Very Wet [miroc]	275	135	375	155	40	1133	59	320	397	259	1200	390	130	1164	3	719	419	297
	Warm/Wet [giss]	453	256	601	210	38	1552	118	375	514	753	1417	572	104	1374	23	481	552	467
	Warm/Dry [fio]	187	99	483	45	4	1510	16	172	159	475	946	374	14	1201	5	176	367	174
15-May	historical	429	277	288	105	29	1568	37	474	416	593	1341	403	227	1289	25	436	496	409
	Central [ccsm]	263	169	177	35	27	1385	22	352	161	248	988	216	174	1066	13	267	348	196
	Hot/Dry [hadgem2]	56	44	32	12	4	990	3	96	133	114	586	54	35	677	0	45	180	50
	Hot/Very Wet [miroc]	174	122	106	58	33	1061	18	276	263	173	970	184	217	922	4	395	311	179
	Warm/Wet [giss]	351	257	208	94	35	1519	33	403	433	530	1292	338	241	1239	23	404	462	345
	Warm/Dry [fio]	208	120	168	31	4	1481	10	211	167	373	1053	244	87	1064	6	239	342	188

Snow Covered Area % change (0.5 meter snow depth threshold)

	Scenario	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average	Median
1-May	Central [ccsm]	-10	-25	-17	-47	44	-7	13	-11	-50	-47	-10	-24	-21	-5	-27	5	-16	-8
	Hot/Dry [hadgem2]	-64	-77	-68	-65	-61	-21	-63	-68	-33	-58	-26	-61	-80	-19	-91	-67	-42	-64
	Hot/Very Wet [miroc]	-41	-46	-49	-14	53	-28	-35	-24	-5	-65	-10	-41	85	-14	-85	88	-23	-29
	Warm/Wet [giss]	-3	3	-18	16	44	-2	31	-11	23	1	6	-4	48	1	6	26	2	11
	Warm/Dry [fio]	-60	-60	-34	-75	-85	-4	-82	-59	-62	-36	-29	-37	-79	-11	-79	-54	-32	-59
15-May	Central [ccsm]	-39	-39	-38	-67	-5	-12	-42	-26	-61	-58	-26	-47	-23	-17	-48	-39	-30	-52
	Hot/Dry [hadgem2]	-87	-84	-89	-88	-85	-37	-93	-80	-68	-81	-56	-87	-85	-47	-98	-90	-64	-88
	Hot/Very Wet [miroc]	-60	-56	-63	-44	13	-32	-53	-42	-37	-71	-28	-54	-4	-28	-86	-9	-37	-56
	Warm/Wet [giss]	-18	-7	-28	-10	20	-3	-13	-15	4	-11	-4	-16	6	-4	-8	-7	-7	-16
	Warm/Dry [fio]	-52	-56	-42	-71	-85	-6	-74	-55	-60	-37	-22	-39	-62	-17	-78	-45	-31	-54

Table 5-7: ROMO Snow Covered Area (0.5 m snow depth threshold) Top: Area (km^2) in historical and five future scenarios. Bottom: percent change in future simulations compared to historical. Average and Median values also shown.

6 Comparing results with McKelvey

An overview of the methodological similarities and differences between this study and McKelvey et al (2011) was presented in section 2.2. The differences in aims of these studies leads to challenges in making a direct comparison. McKelvey investigated persistence of even a snow cover to May 15th as a correlate of wolverine habitat, as noted in Aubry et al (2008). This study focuses on high-elevation terrain and on the persistence of deeper snowpack. Nonetheless some general statements can be made relating the two studies. Figure 5-24 [THIS IS FIG 5-26] shows snowcover under McKelvey's historic and "miroc 2080's" (or hotter) scenario. The GLAC and ROMO areas have been outlined. A close examination of this figure shows that snow cover persists in our study areas, even for their hotter scenario of change (miroc "2080's). The greatest loss of snow cover in McKelvey occurs at lower elevations than were included in GLAC or ROMO. Because of the increased resolution of our study we are able to consider whether any pockets of snow with depth greater than 0.5 meters will persist.

Commented [GJM18]: Explain this was their worst case. AJR – they don't use use the term "Worst Case" – they just use miroc, We coul say the warm/warmer and hot/hotter scenarios, but I'm not comfortable calling them "worst case" and definitely not best case.

The choice of future climate scenarios differs somewhat from McKelvey. We have intentionally included scenarios that represent the range of possibilities indicated by the CMIP5 climate models. McKelvey used climate model output from Littell, who chose scenarios based solely on projected warming. For GLAC, this choice fortuitously included a range of precipitation changes as well. For ROMO, however, McKelvey's scenarios include only a narrow range of precipitation change, where we include scenarios with significantly increased wintertime precipitation as well as scenarios with drying. This is a significant factor, given the buffering effect that increased precipitation has on snowpack loss at high elevations.

While McKelvey focused snowpack projections entirely on the long-term average, we investigate how climate variability – the sequences of wet and dry years -- intersects with scenarios of change. For ROMO in particular we find that dry years behave differently than wet years, with dry years benefitting from the increased precipitation in several of our future scenarios. This emphasizes the importance of planning for a range of possible climate scenarios, particularly regarding the direction of change in wintertime precipitation.

The question arises as to how the fine-scale projections of snow persistence in other areas might reasonably be inferred from the two study areas considered here. Figure 5-24 indicates many areas in the western United States that show persistence of snow cover in McKelvey's scenarios, even in the more extreme scenarios. We have investigated two study areas: a northern, relatively wet and low-elevation area GLAC, and a southern, relatively dry, and very high elevation area (ROMO). In both areas we find general declines in snow covered area under most future scenarios. The GLAC study area is broadly similar in its climate to much of the high northern Rockies, while ROMO shares features with the high mountain ranges of the Central Rockies. For areas in the McKelvey maps that show retention of snow on the higher mountain ranges it is physically reasonable to presume that a finer scale simulation would show the retention of areas of snow > 0.5 m on May 15th. Extending this beyond the general area of the Rocky Mountains is problematic. Even within the Rockies, in regions where McKelvey's results show widespread loss of snowpack it is probably not reasonable to conclude one way or the other whether a finer scale analysis would identify snow refugia.

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8 Glossary

- **Aspect:** compass direction that slope faces
- **Baseline period 1916-2000**: Deltas (changes) computed (monthly average delta) for "2040's and "2080's" compared to the 1916-2000 baseline.
- **CanESM:** A CMIP5 climate model the Canadian Centre for Climate Modeling and Analysis (canesm2.1.rcp85), forced with the RCP 8.5 higher emissions pathway, used in this report as a future scenario (Hot/Dry scenario for GLAC only) that has relatively higher increase in temperature (+~4.5 C) and about +20% increase in precipitation (See Figure 5-7)
- **Climate Sensitivity:** Regionally speaking, it is the response of a climate model for a given amount of greenhouse gas increase. More narrowly defined it is the global average temperature increase that results from a doubling of carbon dioxide over pre-industrial values.
- **CMIP3, CMIP5:** Coupled Model Intercomparison Project Phases 3 and 5. "Foundational" collections of climate model projections, used in the Intergovernmental panel on Climate Change (IPCC) 2007 and IPCC 2013 reports, respectively
- **CNRM:** A CMIP5 climate model from the French National Centre of Meteorological Research (cnrm-cm5.1.rcp85),used in this report as a future scenario (Central scenario for both GLAC and ROMO) that is relatively close to the ensemble mean in temperature increase (+~2.5 ºC) and +~5-8% increase in precipitation (See Figure 5-7).
- **DEM:** Digital elevation model
- **DSHVM:** Distributed Hydrology Soil Vegetation Model
- **ESM:** earth system models, see GCM.
- **FIO:** A CMIP5 earth system model from the First Institute of Oceanography, State Oceanic Administration of China (fio-esm.1.rcp85), used in this report as a future scenario (Warm/Dry scenario for both areas) that is relatively lower in temperature increase (+~0.8-1.6 ºC) and -~5% decrease in precipitation (See Figure 5-7).
- **FLH:** Atmospheric freezing level height is the altitude in the free atmosphere at which the temperature is 0 °C
- **GCM:** Global Climate Model, 6 were used for this report from the IPCC 2013 class of models; X of these are actually earth system models (ESM), an advanced type of GCM which have the added capability to explicitly represent biogeochemical processes that interact with the physical climate. GCM is used as a general term referring to both kinds of models, ESM is used specifically for earth system models.

- **GISS:** A CMIP5 climate model from the NASA Goddard Institute for Space Studies (giss-e2-r.1.rcp45), used in this report as a future scenario (Warm/Wet scenario for both areas). Referred to as the "Least Change" scenario because it that is relatively lower temperature increase (+~1-1.3 ºC) and +~7-10% increase in precipitation (See Figure 5-7).
- **GLAC:** An area in Glacier National Park used as a spatial unit of analysis in this report
- **HADGEM:** A CMIP5 earth system model from the United Kingdom Meteorological Office Hadley Center (hadgem2-es.1.rcp85) used in this report as a future scenario (Hot/Very Wet scenario for ROMO only) that has relatively higher temperature increase (+~ 3.5 ºC) and -~5% decrease in precipitation.
- **Internal climate variability**: The variations in the climate, even for 30-year and longer averages, that can occur due to the interactions of the atmosphere, ocean, inland surface and cryosphere. This occurs even in the absence of anthropogenic climate change.
- **MODIS:** Moderate Resolution Imaging Spectroradiometer, a satellite remote sensing instrument carried on the Terra satellite
- **MIROC:** A CMIP5 earth system model from the Japanese Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies (miroc-esm-chem.1.rcp85), used in this report as a future scenario (Hot/Wet scenario for both areas). Referred to as the "Greatest Change" scenario because it has the highest temperature increase of the scenarios (+~4 ºC) and +~10-18% increase in precipitation (see Figure 5-7). This ESM has an atmospheric chemistry (CHEM) component coupled to the MIROC-ESM (http://maca.northwestknowledge.net/GCMs.php).
- **NDSI:** Normalized Difference Snow Index, a measure of snow cover, has a has a linear relationship to fractional snow cover (FSC)
- **North American Freezing Level Tracker**: NCEP/NCAR Global Reanalysis 2.5º x 2.5º grid data (http://www.wrcc.dri.edu/cwd/products/)
- **Octants:** Topographic aspect, or compass direction, was classified into eight directional bins, each representing 45° of compass arc, e.g; NW, N, NE, E, SE, S, SW, and W
- **Resolution:** The VIC modeling that was the basis for McKelvey was performed on a regular grid in latitude and longitude, with a grid size of 1/16 degree on a side. The distance between degrees of longitude varies due to the curvature of the Earth, and the east-west dimension of a gridbox is smaller than the north-south distance by a factor of the cosine of latitude. At 40°N latitude, the southern extent of Rocky Mountain National Park, the gridbox is ~5km by 7 km (~37km^2). Grid boxes at Glacier National Park (~48°N) are slightly smaller. When referring to the McKelvey study we will use the "1/16 degree" notation. The DHSVM modeling used in this study was performed on a uniform grid in the Universal Transverse Mercator (UTM) map projection, which allows a near-uniform grid size of 250m by 250m (0.0625 km^2) in both of the study areas.
- **ROMO:** An area in and around Rocky Mountain NP used as a spatial unit of analysis in this report
- **SCA:** Snow Covered Area (km^2)
- **SDD:** Snow Disappearance Date, the first Day of Year after March 1 where pixel is snow-free, defined as the date which NDSI/100 was less or equal to 0.1.
- **SNODAS:** Snow Data Assimilation System, a product of the NOAA National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC)

- **SWE:** Snow water equivalent (mm). For May, snow depth is assumed to be ~ 2.5 *SWE
- **TopoWx:**
- **Snow covered area, total:** Total area covered by snow within the study boundaries in square kilometers (km^2)
- **Snow covered area, fractional:** Percentage of the total land area that is covered by snow; this can be within the study boundaries, aspect area, or elevation bands
- **VIC:** Variable Infiltration Capacity hydrologic model
- **UTM:** Universal Transverse Mercator spatial coordinates

FIGURES – see separate file

From:	Stephen Torbit
To:	John Guinotte
Subject:	RE: report edits
Date:	Monday, July 17, 2017 9:12:30 AM

Got it, thanks. Will incorporate my comments and get it to Andrea today.

Thanks
Go have fun..

ST

Stephen C. Torbit
Assistant Regional Director
Science Applications
U.S. Fish and Wildlife Service
134 Union Blvd.
Lakewood, Colorado 80228
303-236-4602 – Office
720-626-7504 – Cell

From: Guinotte, John [mailto:john_guinotte@fws.gov]
Sent: Sunday, July 16, 2017 7:26 AM
To: Stephen Torbit
Subject: report edits

Hi Steve, I removed several of my comments in this version. I got rid of everything that had to do w 1m snow depth and also removed all requests related to analysis of inferred den elevation bands in ROMO. I still think they should go into more detail on den elevation bands in GLAC. We know they are there and it is relevant to the questions we are trying to answer. We can go into detail on the romo elevation bands in the SSA. Also, I think June 1 results still remain irrelevant in my opinion. I won't make a big deal about it if they leave them in, but they don't do us any good for wolverine. June 1 results could/should be included in the peer-reviewed publication. I think the only set of figs they need to add is the graphs with total area of snow, this is in addition to the percent cover change ones they already have done. Let me know if there is more you want me to do. I'm in Seattle now and flying to AK Sunday am, but will have a few hours on the plane to work on this and should have internet in Bethel so can send you something.
Best, John
John Guinotte
Spatial Ecologist
Ecological Services
U.S. Fish and Wildlife Service
Mountain Prairie Region 6
134 Union Blvd., Lakewood, CO 80228
303-236-4264
john_guinotte@fws.gov