From: Rodger Steinke
To: Marissa Davis
Subject: Re: Referral Request for Planet Bluegrass Conditional Use
Date: Wednesday, December 1, 2021 9:03:12 AM
Attachments: image001.png

I don't see any issue with this as far as the electrical is concerned

On Mon, Nov 29, 2021 at 4:15 PM Marissa Davis <mdavis@townoflyons.com> wrote:

> Hello-
>
> I have attached a referral request. Please review and send back any comments. If you are receiving this because you are the Chair of a Town Commission please schedule a time to meet as an entire board to get the boards comments before returning the referral request. If you have questions please let me know.
>
> Thanks,
>
> LYONS COLORADO
>
> Marissa Davis
> Deputy Town Clerk
> 303-823-6622, ext. 21
> mdavis@townoflyons.com

Xcel Energy[SM]
PUBLIC SERVICE COMPANY

Right of Way & Permits

1123 West 3rd Avenue
Denver, Colorado 80223
Telephone: **303.571.3306**
Facsimile: 303. 571. 3284
donna.l.george@xcelenergy.com

December 21, 2021

Town of Lyons
PO Box 49
Lyons, CO 80540

Attn: Marissa Davis

Re: Planet Bluegrass Conditional Use Review

Public Service Company of Colorado's (PSCo) Right of Way & Permits Referral Desk has reviewed the conditional use review documentation for **Planet Bluegrass**. Please be aware PSCo owns and operates existing natural gas *distribution* facilities along the southern and northern property boundaries of the west parcel. There is also a gas *service* line in the area of the proposed West Gate on the east parcel

PSCo reminds the developer to call the Utility Notification Center by dialing 811 for utility locates prior to construction of the proposed perimeter fencing. Use caution and hand dig when excavating within 18-inches of each side of the marked facilities. Please be aware that all risk and responsibility for this request are unilaterally that of the Applicant/Requestor.

Should the project require any new natural gas service, or modification to the existing gas service facilities in each parcel, the property owner/developer/contractor must complete the application process via xcelenergy.com/InstallAndConnect.

Donna George
Right of Way and Permits
Public Service Company of Colorado dba Xcel Energy
Office: 303-571-3306 – Email: donna.l.george@xcelenergy.com

From:	Bilobran - CDOT, Timothy
To:	Philip Strom
Subject:	Re: Referral Request for Planet Bluegrass Conditional Use
Date:	Thursday, January 20, 2022 4:06:32 PM
Attachments:	image002.png image005.png image003.png image004.png image006.png image001.png image007.png

---

Yes that is correct Philip.

Tim

On Thu, Jan 20, 2022 at 4:04 PM Philip Strom <PStrom@townoflyons.com> wrote:

> Hi Tim, circling back to this conversation after our meeting with Planet Bluegrass (Zach) a few weeks ago, my understanding from the meeting is that PB would be able to continue to operate under their State Highway Access Permit as the number of events does not exceed 29, correct? I plan to include this requirement in the approval of their Conditional Use Request to the Town, thanks.
>
> Philip Strom, LEED Green Associate
> Director of Community Development | he, him, his
> Cell: 970-576-4907
> pstrom@townoflyons.com
>
>
>
> ---
>
> **From:** Bilobran - CDOT, Timothy <timothy.bilobran@state.co.us>
> **Sent:** Thursday, December 23, 2021 12:58 PM
> **To:** Philip Strom <PStrom@townoflyons.com>
> **Cc:** Allyson Young - CDOT <allyson.young@state.co.us>; Marissa Davis <mdavis@townoflyons.com>; Katrina Kloberdanz - CDOT <katrina.kloberdanz@state.co.us>
> **Subject:** Re: Referral Request for Planet Bluegrass Conditional Use
>
> Philip,

Thank you for sending in the document. I've actually spent a good chunk of my day researching this and getting the history. Ultimately CDOT is going to stick with the comment that the applicant needs to provide a new traffic study at the stage. Our thought process is:

1. Under the statewide access code, whether or not auxiliary lanes are required on the highway uses the 30th busiest days peak hour traffic volumes as a decision point. There's probably no question that the festivals generated enough traffic to require auxiliary lanes, but the thinking back in 2016 when the original permit was issued for the camping was that there would be fewer than 30 days of camping in a calendar year. The applicant requested camping for 10 days back in 2016. I've included this 2016 permit for your records.

2. Since the applicant did not begin the camping right away and completed the access changes, the 2016 permit expired in 2017. Planet Bluegrass approached me about re-issuing the 2016 permit in 2018. I've included that permit as a reference. Please note that the application date on this permit is January 2018 and the permit was first issued in February 2018.

3. The letter Planet Bluegrass wrote indicates that the included traffic study was approved. I actually do not believe CDOT saw this traffic study. The study is dated March 2018, which is two months after the application and one month after we issued the permit. I believe it was a study approved by the town but CDOT did not comment and offer feedback.

4. Reading through the study just now, it actually indicates that the 10 days of camping we approved in 2016 actually has morphed already into at least 20 days of high traffic. You'll see that the study indicates there are peak hours on both Thursdays and Saturdays. I would have to assume that Sunday traffic also carries a high peak hour volume as well for people leaving the festival.

5. Wrapping up, the number of events and size of the events are actually less of a concern then what the 30th busiest day of traffic is using the access points. Had CDOT seen the study in 2018 we would've requested the same 30th busiest day metric. That's the key metric and whether or not auxiliary lanes need to be constructed on the highway. The upcoming study needs to specifically state what the 30th busiest yearly days peak hour traffic counts are.

6. On a related note, CDOT policy is that after three years the traffic studies require updating anyways. The traffic in Northern Colorado is simply growing so fast exponentially. Specific to this highway in your community, Rocky Mountain National Park saw banner attendance last year. Traffic assumptions made in 2016 and 2018 are not necessarily valid in

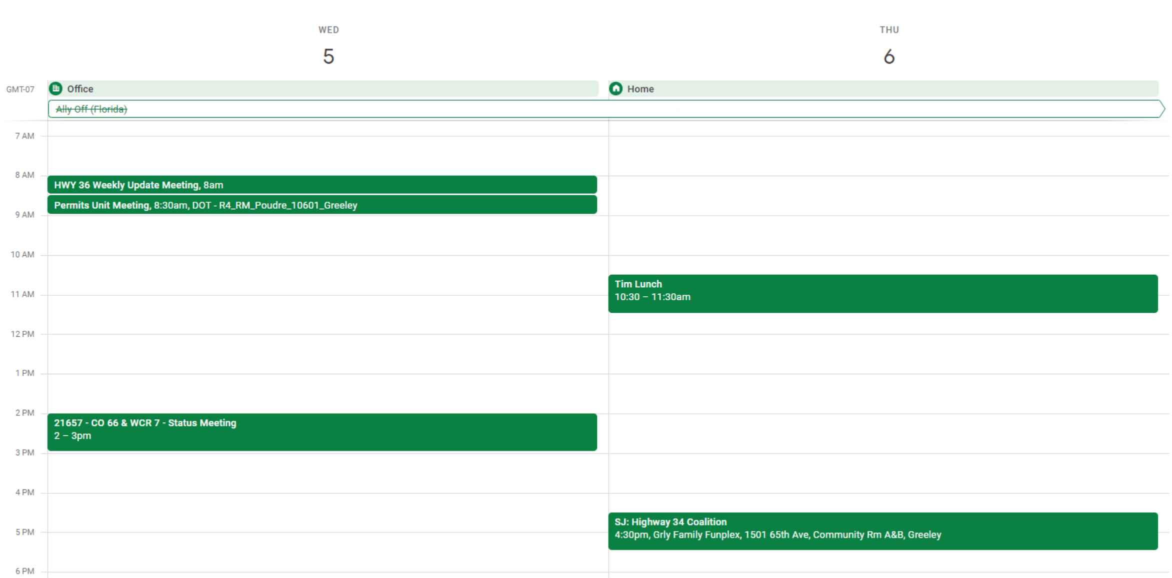
2022. We have to adapt to changing circumstances.

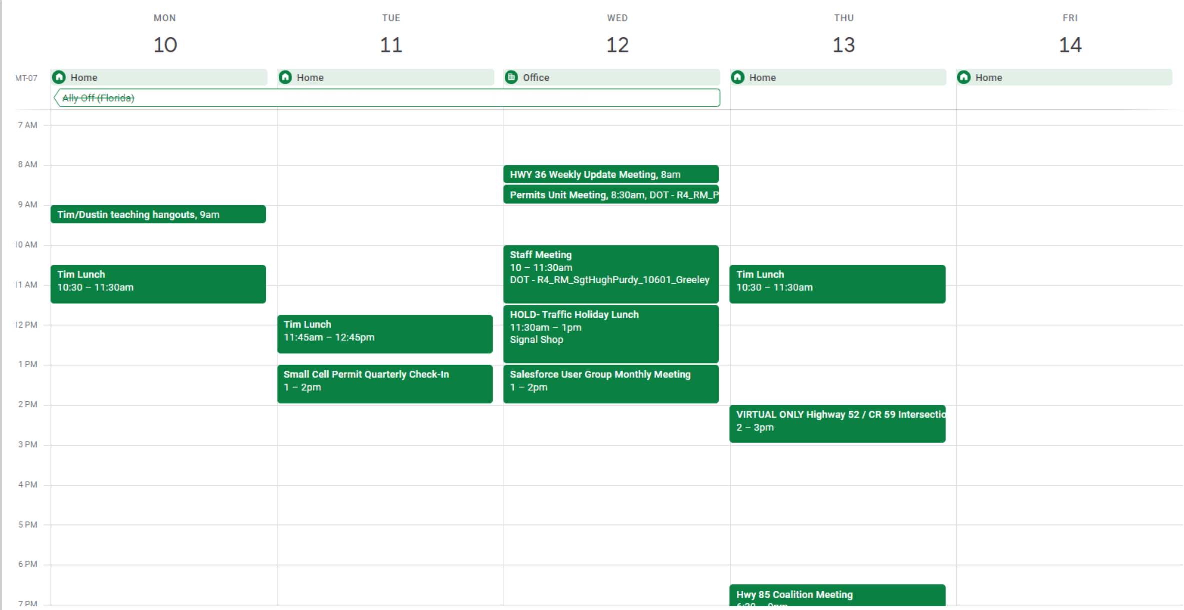
7. Finally, I realize there’s an argument to be made that the flaggers controlling the highway have prevented any serious accidents, so why is CDOT pushing for possible auxiliary lane construction? Flaggers themselves are statistically a potential crash hazard in that queue of stopped cars. Just because there has not been an accident is not grounds to assume that there never will be an accident, especially as surrounding traffic increases. Additionally, with the construction of the underpass we are no longer writing Special Use Permits for the flaggers. Some of the "not technically approved" flagging we saw last summer was not up to MUTCD or CDOT standards. Please see the attached picture as an example of non-standard traffic setup. The blue canopy is actually placed in the center of the highway as a crash hazard.

We've always held that building auxiliary lanes on the highway is a possibility. It's written on that 2016 permit even.

I am going to copy and paste my calendar below for the first few weeks of the new year. Please feel free to share this with the applicant if they would like to have a video conference to discuss any of these comments. Thank you.

Tim





On Sun, Dec 12, 2021 at 3:47 PM Philip Strom <PStrom@townoflyons.com> wrote:

Hi Tim, following up with additional information from Planet Bluegrass, see attached and their response below:

> *I prepared the attached document in hopes of clarifying some of the questions that CDOT had. Would you be able to pass this along to Tim/CDOT and please let me know if we can provide any additional information, etc. I'm also happy to call/meet in person if anything needs further clarification. Our operation is quite complicated, so I hope this all makes sense.*

> *Our goal is to get our Conditional Use Review approved with the understanding that we are still limited in use of the Farm by our CDOT access permit and would need to seek an updated permit to increase our use.*

Let me know if you need anything further and happy to coordinate a meeting or call if necessary, thanks.

LYONS COLORADO
Philip Strom, LEED Green Associate
Interim Town Planner
303-823-6622, ext. 25
pstrom@townoflyons.com

From: Bilobran - CDOT, Timothy <timothy.bilobran@state.co.us>
Sent: Thursday, December 2, 2021 5:32 PM
To: Philip Strom <PStrom@townoflyons.com>
Cc: Allyson Young - CDOT <allyson.young@state.co.us>; Marissa Davis <mdavis@townoflyons.com>
Subject: Re: Referral Request for Planet Bluegrass Conditional Use

OK thank you for sending the map. That helps immensely with understanding what they are proposing. At this point CDOT thinks there's enough probability that the traffic will be increasing with this proposal by greater than 20% on the event days that we'd want some professionally prepared traffic memo at a minimum to discuss all the different event scenarios and how the camping impacts those scenarios. I understand the major event threshold is going up but what about more mid tier events? Will they have camping?

The applicants submittal letter caged the camping as a net reduction for traffic. I acknowledge it's a possibility but I think there's a possibility as well that it increases traffic by nature of the campsite. People are going to be coming and going every time they want to go to a town restaurant or run to the convenience store. The letter alludes to this possibility in the economic benefits to the town section, stating that they campers are likely to visit the town for goods and services. I think the engineering warrants a professional looking at it and adding their stamp.

Regardless even apart from the town process the CDOT access permits will need to be updated so we will require the traffic information on our end.

I realize the big events still may have police presence to assist the motorists. I want to make sure that when the police aren't around, the camping isn't generating enough traffic to warrant auxiliary lines / other mitigation as well.

Let me know if you have any questions. Finally for our standard right of way request we ask for 75 feet from centerline if that amount is not already present. Thank you.

Tim

On Tue, Nov 30, 2021 at 11:35 AM Philip Strom <PStrom@townoflyons.com> wrote:

Hi Tim, adding two plans for further information showing the parcel locations of the “Farm” and “Ranch”. The main request is to add camping to the farm (which may have impacts, but would be determined through this review). They did not provide a traffic study and regarding the number of events, mid-tier events (current 1,000 attendee max, requesting increase to 3,000 max) would occur up to 10 times per year at the Ranch (none at Farm). Major events are limited to 8 times per year. There will also be Sunday line-ups at the Farm with vehicle parking for Major Events. There would be access points for parking at both the Ranch and Farm. Let me know if you need anything else, thanks.

Philip Strom, LEED Green Associate
Interim Town Planner
303-823-6622, ext. 25
pstrom@townoflyons.com

From: Marissa Davis <mdavis@townoflyons.com>
Sent: Tuesday, November 30, 2021 10:52 AM
To: Bilobran - CDOT, Timothy <timothy.bilobran@state.co.us>
Cc: Philip Strom <PStrom@townoflyons.com>
Subject: RE: Referral Request for Planet Bluegrass Conditional Use

Here is the application for this. I know that Philip will be able to answer any additional questions that you may have.

Marissa Davis
Deputy Town Clerk
303-823-6622, ext. 21
mdavis@townoflyons.com

From: Bilobran - CDOT, Timothy <timothy.bilobran@state.co.us>
Sent: Monday, November 29, 2021 4:54 PM

To: Marissa Davis <mdavis@townoflyons.com>; Philip Strom <PStrom@townoflyons.com>
Subject: Re: Referral Request for Planet Bluegrass Conditional Use

Philip and Marissa,

Did the applicant provide any traffic study information for the traffic increase from grazing to camping? Which parcel is this on? Is it using the main access point? Is this for every weekend in the summer?

Tim

On Mon, Nov 29, 2021 at 4:17 PM Marissa Davis <mdavis@townoflyons.com> wrote:

> Hello-
>
> I have attached a referral request. Please review and send back any comments. If you are receiving this because you are the Chair of a Town Commission please schedule a time to meet as an entire board to get the boards comments before returning the

referral request. If you have questions please let me know.

Thanks,

Marissa Davis
Deputy Town Clerk
303-823-6622, ext. 21
mdavis@townoflyons.com

--

Tim Bilobran
Region 4 Permits Manager

O 970.350.2163 | C 970.302.4022 | F 970.350.2198

timothy.bilobran@state.co.us | codot.gov | www.cotrip.org

10601 W. 10th Street, Greeley, CO 80634

--

Tim Bilobran
Region 4 Permits Manager

O 970.350.2163 | C 970.302.4022 | F 970.350.2198

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10601 W. 10th Street, Greeley, CO 80634

REFERRAL REQUEST

LYONS
COLORADO

Project Name: Planet Bluegrass Conditional Use Review
Today's Date: 11/29/2021
Comments Due By: 12/17/2021

The Town of Lyons has received the following item for review:

Applicant: Craig Ferguson
Zoning District: Commercial Entertainment
Location: 19680 North Saint Vrain Drive Lyons, Co

Project Description: The applicant is requesting a conditional use to modify the approved site plan and keynotes to address current and anticipated needs of the site. The primary modification is to the south grazing area of the Planet Bluegrass Farm to accommodate camping during major events. This includes changing the use to accommodate camping, storage, and an accessory dwelling. Currently a public hearing is being scheduled and will be noticed when confirmed. The Town has received a substantially complete application.

The application is submitted to you for review and comments. Please reply by the above-listed date so that we may give full consideration to your recommendation. Any response not received before or on this date will be deemed to be a neutral response.

If you have any questions regarding this application please call the Planner Philip Strom at 303-823-6622 x25 or email him at pstrom@townoflyons.com. Please note that only a portion of the submitted documents have been enclosed. If you desire to review the entire file please call the Deputy Town Clerk Marissa Davis at 303-823-6622 x 21.

DOUBLE GATEWAY TO THE ROCKIES

Please check the appropriate response below or send a letter.

	We have reviewed the proposal and have no conflicts.
XX	See attached letter for comments regarding this
	Please note the following concern:

Signature: Aaron Caplan
Date: 9 Dec 2021
Printed Name/Agency: Aaron Caplan, Director of Utilities & Engineering

Please mail you comments to: Town of Lyons, PO Box 49, Lyons, CO 80540, ATTN. Marissa Davis or fax them to: 303.823.8257 or email them to: mdavis@townoflyons.com.

TELEPHONE
303.823.6622

FACSIMILE
303.823.8257

432 5TH AVENUE • P.O. BOX 49
LYONS • COLORADO 80540

TOWNOFLYONS.COM

7 Dec 2021

RE: Referral Request Planet Bluegrass

Any changes to grade or additional structures on either property would require a drainage report showing that there is no change to how run off flows from one property to another property. In this specific situation all drainage may go into the N. St. Vrain before another property. This will require a review for stormwater quality and possible stormwater facilities to protect water quality.

The existing water service connection for 19680 N St. Vrain Dr. is a ¾" service. Additional use of that service would require an estimated annual consumption to determine if a larger service line would be required. Upgrading a service line does require dedicating additional water rights to the town and additional connection fees. Current water consumption at the property follows the residential average of 36,000 gallons a year.

A 2nd service connection would also require additional water rights dedicated to the town and additional connection fees.

Accessory dwelling units (ADU's) are expressly prohibited from their own connection to the town utilities. Code requires that they connect to the primary dwelling units utilities behind the meter.

The Eagle Canyon Subdivision Sewer system is connected to what is called a lift station. This lift station then pumps sewage under pressure, rather than a standard gravity sewer line, to a location in town where it can then follow the gravity sewer to the wastewater facility. This lift station is 28 years old and has been documented in the 2016 Sanitary Sewer System Expansion Feasibility Study; "We recommend that should the Town plan for a sewer system in Apple Valley that the connection point be either at the existing Eagle Canyon lift station location, assuming it's rebuilt, or at a new lift station at the west end of Main Street."

Septic systems are not allowed in Town limits see LMC Sec. 13-4-60. - Connection to wastewater system mandatory.

This location is currently served by Longmont electric so there are no concerns with regard to electric utilities.

Thank You,

Aaron Caplan
Director of Utilities & Engineering
Town of Lyons

LYONS
COLORADO

DOUBLE GATEWAY
TO THE ROCKIES

TELEPHONE
303.823.6622

FACSIMILE
303.823.8257

432 5TH AVENUE • P.O. BOX 49
LYONS • COLORADO 80540

TOWNOFLYONS.COM

REFERRAL REQUEST

Project Name: Planet Bluegrass Conditional Use Review
Today's Date: 11/29/2021
Comments Due By: 12/17/2021

LYONS COLORADO

The Town of Lyons has received the following item for review:

Applicant: Craig Ferguson
Zoning District: Commercial Entertainment
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The application is submitted to you for review and comments. Please reply by the above- listed date so that we may give full consideration to your recommendation. Any response not received before or on this date will be deemed to be a neutral response.

DOUBLE GATEWAY TO THE ROCKIES

If you have any questions regarding this application please call the Planner Philip Strom at 303-823-6622 x25 or email him at pstrom@townoflyons.com. Please note that only a portion of the submitted documents have been enclosed. If you desire to review the entire file please call the Deputy Town Clerk Marissa Davis at 303-823-6622 x 21.

Please check the appropriate response below or send a letter.

	We have reviewed the proposal and have no conflicts.
	See attached letter for comments regarding this proposal.
X	Please note the following concern: The following motion was unanimously approved at the 12/1/21 UEB meeting:

Planet Bluegrass needs to submit a full utility report by a licensed professional engineer in Colorado including discussion of tap fees and water shares and needed associated infrastructure that will be used.

Signature: Jim Kerr *Jim Kerr*
Date: December 11, 2021
Printed Name/Agency: Town of Lyons Utilities and Engineering Board (UEB)

Please mail you comments to: Town of Lyons, PO Box 49, Lyons, CO 80540, ATTN. Marissa Davis **or fax them to:** 303.823.8257 **or email them to:** mdavis@townoflyons.com.

TELEPHONE
303.823.6622
FACSIMILE
303.823.8257
432 5TH AVENUE • P.O. BOX 49
LYONS • COLORADO 80540
TOWNOFLYONS.COM

From:	Philip Strom
To:	"Rosi Dennett"
Cc:	"Zach Tucker"; Victoria Simonsen; Aaron Caplan
Subject:	RE: Utilities Referral Responses
Date:	Thursday, December 16, 2021 12:33:00 PM
Attachments:	image003.png image004.png image005.png

Hi Rosi, I spoke with Aaron and he met with the UEB last night, they are OK with Planet Bluegrass providing the information later during building permitting. However, they still want to ensure they have a comprehensive understanding of the development and potential impacts, so they request that along with the first building permit submission, comprehensive drainage and utility reports are provided for the entire final build-out. Thanks.

Philip Strom, LEED Green Associate
Interim Town Planner
303-823-6622, ext. 25
pstrom@townoflyons.com

From: Philip Strom
Sent: Monday, December 13, 2021 12:31 PM
To: Rosi Dennett <rosidennett@gmail.com>
Cc: Zach Tucker <zach@bluegrass.com>; Victoria Simonsen <vsimonsen@townoflyons.com>; Aaron Caplan <ACaplan@townoflyons.com>
Subject: RE: Utilities Referral Responses

Thanks Rosi, we will discuss internally on potential options to move forward with the phased development. Yes, any details on the proposed phasing and timeline would be helpful.

Philip Strom, LEED Green Associate
Interim Town Planner
303-823-6622, ext. 25
pstrom@townoflyons.com

Everything in my incoming and outgoing emails may be subject to the Colorado Open Records Act, § 24-72-100.1, et seq.

From: Rosi Dennett <rosidennett@gmail.com>
Sent: Monday, December 13, 2021 11:15 AM
To: Philip Strom <PStrom@townoflyons.com>
Cc: Zach Tucker <zach@bluegrass.com>; Victoria Simonsen <vsimonsen@townoflyons.com>; Aaron Caplan <ACaplan@townoflyons.com>
Subject: Re: Utilities Referral Responses

Hi, Philip.

Thanks for forwarding the referral responses from Aaron and Jim Kerr. Zach is following up with a more detailed explanation to you, but since most of the proposed improvements won't occur for another few years, we don't have detailed plans that an engineer could review to determine utility usage details that have been requested. Rather than requiring Planet Bluegrass to amend the conditional use plan every time they want to build a structure, we thought this proposal could include all of the improvements they anticipate in the next 5 years. Can we simply commit to obtaining Town staff and UEB approval prior to the building permit submittal for each structure? None of the improvements planned for this year will require grading or additional utilities. They plan to use portajohns for the proposed camping area, and it was already graded after the flood recovery work. They only need to mow the area for camping. Can it just be a condition on the approval that prior to building permit submittal for structures that require additional grading and utilities, approval will be obtained from Town staff and UEB?

Thanks for your consideration.

Rosi

On Sun, Dec 12, 2021 at 3:50 PM Philip Strom <PStrom@townoflyons.com> wrote:

> Hi Rosi and Zach, see attached referral response from the Utilities and Engineering Board and Director of Utilities and Engineering requesting additional information, thanks.
>
> LYONS COLORADO
>
> Philip Strom, LEED Green Associate
> Interim Town Planner
> 303-823-6622, ext. 25
> pstrom@townoflyons.com
>
> *Everything in my incoming and outgoing emails may be subject to the Colorado Open Records Act, § 24-72-100.1, et seq.*

--

Rosi Dennett. AICP
FRONT RANGE LAND SOLUTIONS
210 Lincoln St
Longmont,CO 80501
303-682-9729

From:	Marissa Davis
To:	Philip Strom
Subject:	FW: Referral Request for Planet Bluegrass Conditional Use
Date:	Tuesday, November 30, 2021 8:00:03 AM
Attachments:	image001.png

LYONS COLORADO
Marissa Davis
Deputy Town Clerk
303-823-6622, ext. 21
mdavis@townoflyons.com

From: Steve Pischke <spischke@lyonsfire.org>
Sent: Tuesday, November 30, 2021 7:57 AM
To: Marissa Davis <mdavis@townoflyons.com>
Cc: Peter Zick <pzick@lyonsfire.org>; Kevin Boccolucci <kboccolucci@lyonsfire.org>
Subject: Re: Referral Request for Planet Bluegrass Conditional Use

Good morning Marissa - I have looked this referral over and Lyons Fire has no objections to what is being proposed! If you need me to complete the form in addition to this email notice, please let me know
Thanks
Steve

On Mon, Nov 29, 2021 at 4:15 PM Marissa Davis <mdavis@townoflyons.com> wrote:

> Hello-
>
> I have attached a referral request. Please review and send back any comments. If you are receiving this because you are the Chair of a Town Commission please schedule a time to meet as an entire board to get the boards comments before returning the referral request. If you have questions please let me know.
>
> Thanks,

LYONS COLORADO
Marissa Davis
Deputy Town Clerk
303-823-6622, ext. 21
mdavis@townoflyons.com

From:	Victoria Simonsen
To:	Zach Tucker; "Rosi Dennett"; Philip Strom
Cc:	Chris Jain
Subject:	RE: Flood Plain Review
Date:	Friday, February 11, 2022 9:20:21 AM
Attachments:	image001.png

Great questions, Zach!

What used to be called the 100 year flood plain is now the 1% chance and the 500 year is now the .2% chance zones.

A structure in the floodway can have improvements within the footprint (second story, etc.) IF the original structure is floodproofed and elevated.
An open air structure MAY be allowed in a floodway, but has to show a no-rise certificate. The issue with these are that boulders can take out the vertical posts, the roof comes down and creates debris dams or does further damage to other structures down stream. An open air structure would be much easier to approve in a 1% zone.

There are minimal restrictions in the .2% zone. We require a floodplain development application, but there is no fee and usually no issue with approving it. We need it on file to show FEMA that we are reviewing all development in the Special Hazard area.

Happy to answer any other questions you may have. V.

LYONS COLORADO
Victoria Simonsen
Town Administrator
303-823-6622, ext. 19
vsimonsen@townoflyons.com

From: Zach Tucker <zach@bluegrass.com>
Sent: Thursday, February 10, 2022 3:59 PM
To: Victoria Simonsen <vsimonsen@townoflyons.com>; 'Rosi Dennett' <rosidennett@gmail.com>; Philip Strom <PStrom@townoflyons.com>
Cc: Chris Jain <Chris.Jain@murraysmith.us>
Subject: RE: Flood Plain Review

Hi Victoria,

Thank you for providing this review. We were planning on everything in a flood zone needing a permit in the future, but I'm glad to be able to address any non-starters now.

I have reached out to our map team to see if we can incorporate the 2019 flood maps.

I agree, it seems like the storage facility/ADU are most affected, and I'll look to get these updated and try to review if anything else should be changed.

We are aware of the requirements around our proposed permanent bridge, and I know our engineer (Jason from Van Horn) is hoping to discuss that aspect with you in the meeting you were scheduling.

Can you please clarify for me what kind of remodel is allowed in the floodway? Hypothetically, for example, can a second story be added to a footprint already in the floodway if it doesn't alter the footprint? Additionally, are the restrictions around a completely open air structure (i.e. – an open air pavilion with 10 6x6 legs and a roof, but no walls), any different?

Finally, can you please also clarify for me what flood restrictions exist in the 500 year flood plain (I'm assuming that is the .2% chance on the map)

Thank you!

- Zach

From: Victoria Simonsen <vsimonsen@townoflyons.com>
Sent: Wednesday, February 9, 2022 5:32 PM
To: Zach Tucker <zach@bluegrass.com>; Rosi Dennett <rosidennett@gmail.com>; Philip Strom <PStrom@townoflyons.com>
Cc: Chris Jain <Chris.Jain@murraysmith.us>
Subject: Flood Plain Review

Good afternoon,

Chris Jain and I met today to do a cursory review of the proposal from a floodplain administrator perspective. It appears that the person who did these maps did not use the most up-to-date flood plain maps.
They used the FEMA 2012 insurance map, not the 2019 adopted Town of Lyons maps. This makes a fairly significant difference (especially at the Ranch).

I've attached a snapshot of the current map and also a link to it for your engineer.

https://townoflyonsgis.maps.arcgis.com/apps/webappviewer/index.html?id=73b7f105acf04b1fbb1da6d6bd29d293

The biggest issue is that the vehicular bridge and the maintenance building / ADU are in the floodway. This will take an H & H study and no rise certificate to even consider building. The other items that will need consideration are as follows:

At the Ranch

Structures 19 and 21 are both in the floodway. Any changes would require an H & H study and no-rise certificate. Other structures in the AE zone will require elevation.
We will need to double-check 43 and 44 against the new flood maps. Close or 100-year zone?
Are yurts allowed in the floodway? Possibly, depends on the ability to remove them quickly. Staff will need to see the design.

Any temporary structure will need a flood plain permit annually and will need to be removed seasonally.
Will need further clarification on use, timeframe, etc. Cannot stay up year-round without a permit.
It appears that structures 39, 17, 42 will remain in the 500-year zone.
Bldg 34 100 year??

Planet Bluegrass Farm

Structures 11 and 3 are in the 100-year zone. Will need elevated.
South 11, 16 & 17, and 13 are all in the floodway. A permanent bridge is in the foodway and will require H & H study for no rise

13 Temporary bridge – continue to file for permit annually with bridge and abutments being removed annually.

So, at a cursory level, everything is probably doable, but with a few tweaks we may be able to save money and paperwork moving a few structures slightly. The big issue is the maintenance / ADU building smack dab in the floodway. This is just for our consideration at this time. Of course, everything will need a floodplain permit at the time you pursue it. I hope this is helpful to your plans and our discussion. V.

LYONS COLORADO
Victoria Simonsen
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To: Phillip Strom, Town of Lyons
From: Lyons Ecology Advisory Board (EAB)
Subject: Conditional Use Application, Planet Bluegrass
Date: February 17, 2022

EAB's responsibilities include: "The Ecology Advisory Board shall review site designs for all ecologically important parcels of land in order to provide findings, report and make recommendations that uphold the integrity of the environment in the Town…". Thus, we appreciate the opportunity to now provide comment on the Planet Bluegrass Conditional Use Application.

Please note that we were provided the referral only two days ahead of the PCDC hearing on this matter instead of the nominal 14 days. EAB regrets that this effectively prohibited our providing our input for that earlier hearing.

As stated in our 2017 response to the original annexation, the use and development of the PBG Farm should be subject to the Sustainable River Corridor Action Plan (SRCAP) officially adopted by the Town of Lyons in 2014. The SRCAP's Goal 4 specifically states that the Town will "Encourage ecologically responsible restoration and development within the riparian zone." We consider that the annexation proceeded with this understanding.

The EAB has substantial concerns regarding the now-proposed conditional use changes. They appear to largely disregard the regulatory floodway/floodplain use and structure restrictions that Lyons must enforce due to its participation in the National Flood Insurance Program (NFIP). Further consideration by the Town prior to demonstration that such restrictions can be met appears to be premature. At the very least, the application should acknowledge the existence of and nature of the restrictions and indicate ways that they could be met.

We also note that Sec. 16-10-40 from Town Municipal Code indicates an environmental impact analysis is needed to "ensure that any development minimizes environmental impacts, mitigates impacts to wildlife and wildlife habitat, and promotes building practices which benefit the environment and the socioeconomic well-being of current and future residents." PBG Farm contains sensitive wetland habitat as identified in the ongoing Comprehensive Plan process, and an environmental impact analysis should be required to assess the proposed variance. Additionally, we point to Town Code Sec. 17-11-130 that requires that the applicant "provide documentation identifying the extent and location of all wetlands on the property." This also requires the appropriate US Army Corp of Engineers permit or a minimum one-hundred-foot undeveloped buffer between any development activity and…the wetland areas." The PBG proposal does not contain such a buffer.

The proposed development (and some of the modifications already done) do not adequately protect the ecologically sensitive riparian and wetland habitats, particularly along the South Side Grazing Area, and which includes habitat of an endangered species (Prebles Mouse) subject to US Fish and Wildlife permit requirements for such modifications.

We strongly encourage the Town to view this development proposal from a perspective of river and ecosystem health and to consider the negative impacts the of the proposed modifications in this river corridor/wetland area. The issues raised during the original annexation process remain. Many interested parties aside from the EAB were concerned that annexation of the Farm property would make it easier for future development to take place at the site. These concerns were lessened by the agreed upon limits of use: human and vehicle capacity limits, event frequency and duration limits, and, most critically, the protection of the South Grazing Area as an "off-limits" area during PBG events. All as stated in the original annexation plan. The Town must not disregard the protective assurances provided in the original agreement.

In general, we cannot stress enough the value and importance of this sensitive and ecologically critical seasonal wetland and riparian habitat, just upstream of a heavily settled part of the town. Undeveloped riparian habitat is rare along Front Range Colorado. During annual high flows or floods, this area protects and improves water quality, provides fish and other wildlife habitats, temporarily stores floodwater, and helps maintain surface water flow during dry periods. As was the case at annexation, special care is needed now to preserve and enhance these ecosystem services. There are many steps that could be taken for this purpose (preserving a 100 ft buffer next to the river channel, for example, in a more natural state): EAB believes such steps should accompany a conditional use application in this area and given the agreements made on annexation.

Specific Keynote Concerns:

Significant and important changes made in the PBG Farm Conditional Use Application go against the environmentally protective assurances within the original annexation and approved conceptual plan. We are concerned about the increased usage and development in the northern sections of the property. But the proposed activities in the South Grazing Area (2.6 acres) contains previously identified protected ecosystems/habitat and was wisely off-limits to further development and use in the original agreement. The new PBG Farm application contains requests for camping, parking, permanent and temporary year-round lodging facilities, a bathhouse facility, temporary and permanent storage buildings, pedestrian and vehicular bridges, access from Apple Valley Road, and a variety of fencing. Aside from the floodway infringement and floodplain development issues, EAB considers that such developments in the South Grazing Area violate the common understanding and we urge that the protections for the parcel in the original annexation agreement remain in place.

Below are the Keynotes we are most concerned about and the rationale for not supporting the development plans in their current state:

Keynote 4: *Requests expansion for North Campground use for camping and parking to include both Mid-Tier and Major Events.* By now including Mid-Tier events, this request allows for an increase in parking capacity and expands the type and therefore likely the number of events that will use the PBG Farm site. We are concerned that this increase in use will further degrade the grounds, increase erosion, reduce flora and fauna biodiversity, and impinge upon riparian and wetland habitat important to an endangered species and many others.

Keynote 5: *Requests overnight camping in South Grazing Area-Wetlands (2.8 acres). Requests five year-round operating yurts or tiny houses and access from Apple Valley Road. Requests ADU structure and access.* The original agreement allowed for only owner and guest "non-commercial, daytime leisure activities" – essentially banning camping and parking in this area at any time. It was also agreed that there would be no public access from Apple Valley – a particularly important condition voiced by many nearby residents. Permitting camping, residential development and more public access within this area goes directly against Town's obligations as set in the SRCAP to promote "ecologically responsible" development and which motivated the original discussions during the annexation process.

Keynote 6: *Request to add "Mid-Tier" Events to approved farm parking use (in addition to the approved "Major Event" use).* As a result of this change, there is a possibility for an increase in the number of events bringing high volume of campers and vehicles to site.

Keynote 7: The original plan was "for Major Event: use included camping for up to 1,200 people in the North Campground Area only." The new proposal has no limits on camping location, and increases the number of vehicles allowed from 1,000 to 1,400 (a 40% increase).

Keynote 8: *Request for "Major and Mid-tier" event parking expansion into 1.2 wedding venue acreage.* Again, the expansion of parking into new areas and with higher frequency use will cause more degradation of this sensitive land area than was already agreed to and it should not be accepted.

Keynote 11: *Request for future bathhouse structure on the north side of the river.* If the location is found to be within the floodway, a 0 rise certification is required and FEMA could well object to any structure. If outside, in the 100 year floodplain, than a 1 ft rise requirement is in effect. This more lenient criterion still requires designs that do not obstruct floodwater. Given the location in prime Prebles Mouse habitat, the needed construction activities, including any excavation or filling, would require US FWS permitting. We note that Boulder County routinely requires this for such land areas in their jurisdiction and to comply with federal law; we attach a brochure prepared by the County for your information.

Keynotes 13 and 14: *Request for future permanent vehicle bridge and temporary pedestrian bridge spanning the North Saint Vrain River.* These bridges would allow regular, high-intensity public access to previously off-limits, protected areas.

Also, bridges normally require abutments, which can obstruct flood flows and cause unacceptable levels of rise: they must be very carefully designed to meet NFIP restrictions. Applicant has provided no evidence or even discussion that such restrictions will be possible to meet.

Keynote 15: *Requests option to "build perimeter fences around entire property."* Fencing impacts animal movements and flood hazard. Fencing is not generally allowed in the floodway. Even in the floodplain, outside the floodway, it must be designed to not obstruct flow.

Keynote 16: *Requests "future Temporary or Permanent Storage Structures in South Grazing Area."* Items such as shipping containers can pose major downstream hazard in case of flood. EAB is not convinced that the applicant has so far provided a reasonable (even conceptual) plan for meeting floodway and floodplain restrictions that the Town must impose.

Keynote 17: *Requests "future Accessory Dwelling Unit built above storage structure…or as a separate structure, up to 2,000 square feet."* A year-round permanent residence would much increase ecological impact in this area (see the issues raised above, including those regarding floodway and floodplain encroachment).

Keynote 19: *Requests future Bathhouse Structure on South Side of River, up to 2,000 square feet.* See above but note also the unfortunate location of this planned structure as regards the floodway and floodplain.

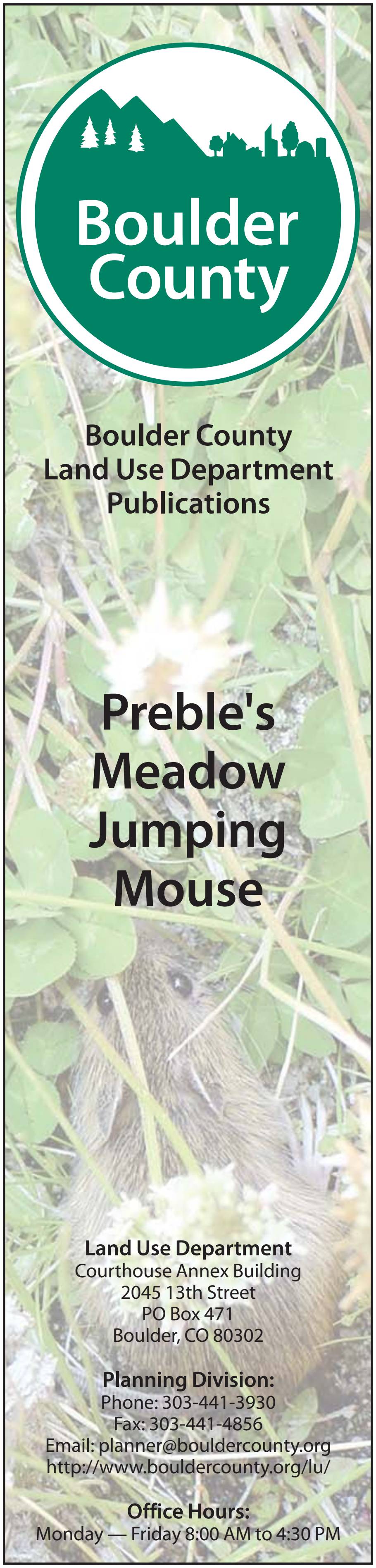
Having expressed EAB's concerns, we have also related questions for the applicant and for the Town.

Questions:

1. How does the application minimize environmental impact and promote ecosystem stability and floodplain protection? The original agreement reassured the Town that such matters were in fact to be addressed. EAB disagrees that temporary use causes minimal impacts. The plans are not temporary in nature, or minimal.
2. Applicant plans the use of fencing to block off specific wetland areas from damage when campers are present. EAB suggests that this "protection" is far from assured, as any fencing in the floodway is subject to strict limits if allowed at all. Again, how can the planned uses be accommodated without further damage to this sensitive land area?
3. How will the likely presence of a federal endangered species be addressed? See attachment.
4. How will PBG maintain ground surfaces suitable for camping? Does PBG have a weed management plan that limits synthetic herbicides? Area has already been largely cleared

of dead wood and downed trees – is this in expectation of mowing? EAB strongly recommends these areas be left in their natural state.

Ecology Advisory Board Members: *Steve Simms (Chair), David Batts, Kurt Carlson, Carse Pustmueller, Bob Brakenridge, Kate Zalzal, Laura Mayo, Greg Lowell (Board liaison)*



Boulder County

Boulder County
Land Use Department
Publications

Preble's Meadow Jumping Mouse

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Office Hours:
Monday — Friday 8:00 AM to 4:30 PM

Preble's Meadow Jumping Mouse

Do You Live Near Streams or Ditches in the Foothills or Plains of Boulder County?

So does a kind of mouse that has been listed for special protection by the U.S. Fish and Wildlife Service. Before you make any substantial changes to your property in places where the mouse might live, you should either check with Boulder County or the Fish and Wildlife Service to find out what these legal protections mean.

The **Preble's meadow jumping mouse** is typically found in thick vegetation within stream corridors, adjacent uplands, and along ditches in the Front Range of Colorado and the southern portion of Wyoming. Steady encroachment into its habitat over the years has reduced the mouse's numbers to the extent that federal biologists believe Preble's faces extinction unless actions are taken now for its protection. To begin that process, the U.S. Fish and Wildlife Service listed the Preble's mouse as a "threatened" species under the federal Endangered Species Act on May 13, 1998.

As a result of this listing, **no federal agencies** may take any action that might result in further jeopardizing the continued existence of Preble's. Actions requiring federal support or approval, such as a right-of-way across federal land or a Section 404 permit for dredging or filling in streams or wetlands, must be formally scrutinized to ensure protection for the mouse.

Activities occurring on **either public or private lands** in which Preble's mice may live are prohibited from harming, harassing, or killing a mouse or damaging its habitat. Generally, if the activity involves new construction, significant changes of surface landscaping, or increased usage by humans or domestic animals it could be in violation of the Endangered Species Act.

The **intention of these provisions** is to protect remaining mice while actions are taken to bring about the species' recovery.

What Does This Mean To You?

Probably little or nothing if you plan to keep using your land in the same manner as you have in the past. But if you are planning to change the use of your land or the level of activity on it and your property has been identified as being in a mapped floodplain or a Preble's meadow jumping mouse conservation area per.

1. Provide the Land Use Department with a site plan and photos showing the proposed development area (structure location, driveway/access, other areas to be disturbed) in context to the existing habitat conditions.
2. The Land Use Department will then send this information to the USFWS to see if there are any mouse or habitat issues associated with the proposal on your property.
   - ✔ If USFWS does not have issues, you may proceed with submitting the application for your proposal and your land use review will begin.
   - ✔ If USFWS requests further field study and/or trapping, this will be considered a prerequisite to you starting the land use review process. Your application will not be considered complete until the possible. Preble's issues have been resolved with USFWS. Most recent direction about receiving proposals is listed on reverse.

The State of Colorado has organized a collaborative process under which interested parties are working to develop habitat conservation plans so that activities along the Front Range can occur in a manner that is compatible with protection of the Preble's mouse. Once these plans are in place, you will be able to work with a county-level review process to ensure that your activity is ok. Until then it is necessary to get clearance from the USFWS. To find out more about the habitat conservation planning process in Boulder County, call Peter Fogg or Kim Sanchez at 303-441-3930 or Ron West at County Open Space and Parks Dept. at 303-678-6269.

U.S. Fish and Wildlife Service Determinations as of September 9th, 2003.

The Following Constitutes Projects that will not Require Additional Review by the U.S. Fish and Wildlife Service (USFWS)

1. Projects that will be attached to an existing structure or within 25 feet of an existing structure (i.e., decks, home additions, garages, sunrooms, sheds).
2. Projects with a total new footprint of 400 square feet or less that occur outside of, but within 300 feet of, the 100-year floodplain.
3. Projects occurring within established maintained, landscaped yards.
4. Projects occurring within areas with established privacy fences.
5. Construction of all non-privacy fences such as, but not limited to, wire or split rail fences within Preble's habitat, provided that fencing will not be used in conjunction with new livestock or cattle grazing practices.
6. Projects that occur outside of, but within 300 feet of, the 100-year floodplain but are separated from Preble's habitat by a paved road more than 25 feet wide.

The Following Constitutes Projects that will Require Additional Review by the U.S. Fish and Wildlife Service (USFWS)

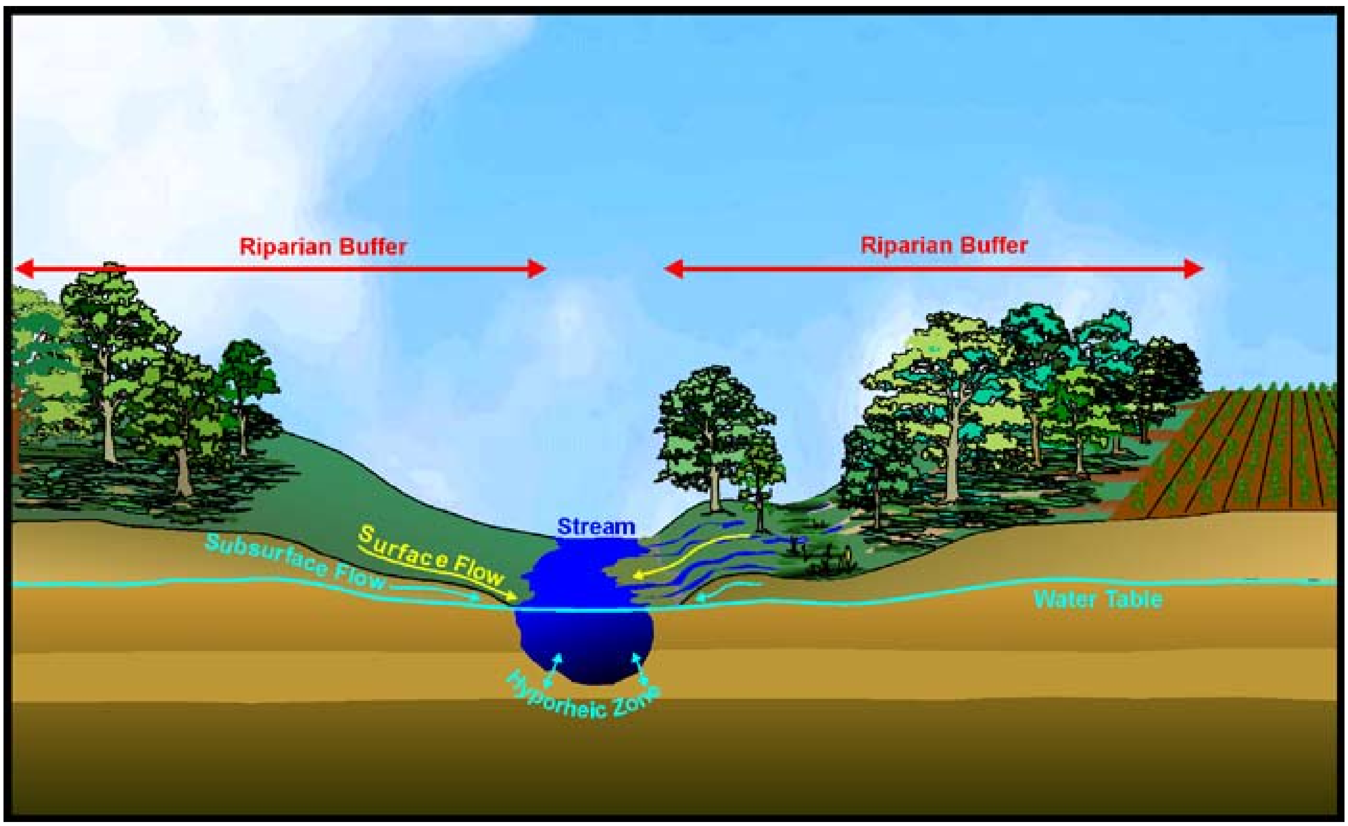
1. Any disturbance of soil or vegetation within the 100-year floodplain.
2. Construction of new privacy fences within 300 feet of the 100-year floodplain.
3. Any permanent structure or temporary disturbance with a new footprint greater than 400 square feet within 300 feet of the 100-year floodplain, except as described above.
4. Leach fields or septic systems that occur within 300 feet of the 100-year floodplain.
5. Construction of fencing to create new grazing areas for livestock or cattle within Preble's habitat.

Preble's Meadow Jumping Mouse - Photo Courtesy: Rob Schorr of the Colorado Natural Heritage Program (CNHP).

United States
Environmental Protection
Agency

Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness:

A Review of Current Science and Regulations



EPA/600/R-05/118
October 2005

Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness:
A Review of Current Science and Regulations

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Notice

The U.S. Environmental Protection Agency through its Office of Research and Development funded, managed, and collaborated in the research described here through in-house efforts. It has been subjected to the Agency's peer and administrative review and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

All research projects making conclusions or recommendations based on environmental data and funded by the U.S. Environmental Protection Agency are required to participate in the Agency Quality Assurance Program. This project did not involve the collection or use of environmental data and, as such, did not require a Quality Assurance Project Plan.

Foreword

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory is the Agency's center for investigation of technological and management approaches for preventing and reducing risks from pollution that threatens human health and the environment. The focus of the Laboratory's research program is on methods and their cost-effectiveness for prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites, sediments and ground water; prevention and control of indoor air pollution; and restoration of ecosystems. NRMRL collaborates with both public and private sector partners to foster technologies that reduce the cost of compliance and to anticipate emerging problems. NRMRL's research provides solutions to environmental problems by: developing and promoting technologies that protect and improve the environment; advancing scientific and engineering information to support regulatory and policy decisions; and providing the technical support and information transfer to ensure implementation of environmental regulations and strategies at the national, state, and community levels.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

The goal of this report is to synthesize the existing scientific literature on the effectiveness of riparian buffers to improve water quality through their inherent ability to process and remove excess anthropogenic nitrogen from surface and ground waters. Due to this ability, riparian buffers often are employed as an environmental management tool by resource management agencies. Despite significant research effort toward understanding the ecological functions of riparian buffers, there remains no consensus for what constitutes optimal riparian buffer design or proper buffer width to achieve maximum nitrogen removal effectiveness. This report does not provide a one-size-fits-all recommendation for such a design or width but rather attempts to identify generalizations and trends extracted from published literature that will aid managers in making decisions about establishing, maintaining, or restoring riparian buffers in watersheds of concern. Although, buffer width stands out as one factor influencing the capacity for buffers to remove nitrogen, numerous other factors described herein play significant roles that must be understood before employing riparian buffers as part of a comprehensive watershed management plan.

Stephen G. Schmelling, Director
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National Risk Management Research Laboratory

Synopsis and Abstract

Synopsis

1) Riparian buffers are vegetated zones adjacent to streams and wetlands that represent a best management practice (BMP) for controlling nitrogen entering water bodies.
2) Current research indicates that riparian buffers of various vegetation types are effective at reducing nitrogen levels in groundwater and streams.
3) Buffer width is only one factor controlling nitrogen removal effectiveness.
4) Subsurface removal of nitrogen in riparian buffers is often high, especially where conditions promote microbial denitrification.
5) Riparian buffers are a single component of comprehensive watershed management plans, which must also include point source and non-point source control of nitrogen.

Abstract

Mayer, P.M., S.K. Reynolds, M.D. McCutchen, and T.J. Canfield. *Riparian buffer width, vegetative cover, and nitrogen removal effectiveness: A review of current science and regulations.* EPA/600/R-05/118. Cincinnati, OH, U.S. Environmental Protection Agency, 2006.

Riparian zones, the vegetated region adjacent to streams and wetlands, are thought to be effective at intercepting and controlling nitrogen loads entering water bodies. Buffer width may be positively related to nitrogen removal effectiveness by influencing nitrogen retention through plant sequestration or removal through microbial denitrification. We surveyed peer-reviewed scientific literature containing data on riparian buffers and nitrogen concentration in streams and groundwater of riparian zones to identify causation and trends in the relationship between buffer width and nitrogen removal capacity. We also examined Federal and State regulations regarding riparian buffer widths to determine if such legislation reflects the current scientific understanding of buffer effectiveness.

Nitrogen removal effectiveness varied widely among riparian zones studied. Subsurface removal of nitrogen was efficient but did not appear to be related to buffer width. Surface removal of nitrogen was partly related to buffer width and was generally inefficient, removing only a small fraction of the total nitrogen flowing through soil surface layers. While some narrow buffers (1-15 m) removed significant proportions of nitrogen, narrow buffers actually contributed to nitrogen loads in riparian zones in some cases. Wider buffers (>50 m) more consistently removed significant portions of nitrogen entering a riparian zone. Buffers of various vegetation types were equally effective at removing nitrogen in the subsurface but not in surface flow. The general lack of vegetation type or buffer width effects on nitrogen removal, especially in the subsurface, suggests that soil type, watershed hydrology (e.g., soil saturation, groundwater flow paths, etc.), and subsurface biogeochemistry (organic carbon supply, high nitrate inputs) may be more important factors dictating nitrogen concentrations due to their influence on denitrification.

State and Federal guidelines for buffer width also varied widely but were generally consistent with the peer-reviewed literature on effective buffer width, recommending or mandating buffers ~7-100 m wide. Proper design, placement, and protection of buffers are critical to buffer effectiveness. To maintain maximum effectiveness, buffer integrity should be protected against soil compaction, loss of vegetation, and stream incision. Maintaining buffers around stream headwaters will likely be most effective at maintaining overall watershed water quality while restoring degraded riparian zones, and stream channels may improve nitrogen removal capacity. Riparian buffers are a "best management practice" (BMP) that should be used in conjunction with a comprehensive watershed management plan that includes control and reduction of point and non-point sources of nitrogen from atmospheric, terrestrial, and aquatic inputs.

Keywords: attenuation, buffer strip, denitrification, groundwater, nitrate, nitrogen, stream, riparian buffer, surface water, watershed, vegetated filter strip

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Appendix

Acknowledgments

We thank D. Niyogi, D. Walters, and S. Wenger for their constructive comments on this manuscript. T. Wiggins assisted in the search for literature and government regulations. K. Tynsky created the cover art. Cover photos were provided by T. Barthelmeh, K. Jewell, and J. Williams. The U.S. Environmental Protection Agency through its Office of Research and Development funded and managed the research described here through in-house efforts. It has been subjected to the Agency's peer and administrative review and has been approved for publication as an EPA document.

Introduction

The U.S. Environmental Protection Agency (U.S. EPA) considers nitrogen one of the top stressors in aquatic ecosystems (U.S. EPA 2002a). Though nitrogen is an important nutrient for all organisms, excess nitrogen is a pollutant that causes eutrophication in surface water and contaminates groundwater (Carpenter et al. 1998). Streams receive chronic nitrogen inputs from upland sources such as fertilizers, animal wastes, leaking sewer lines, atmospheric deposition, and runoff from highways (Carpenter et al. 1998, Swackhamer et al. 2004). Subsequent eutrophication leads to environmental impacts such as toxic algal blooms, oxygen depletion, fish kills, and loss of biodiversity (Vitousek et al. 1997). Nitrate nitrogen (NO_3^-) also is a drinking water pollutant, especially dangerous to infants <6 months old who are at risk of methanoglobin-induced anemia or blue baby syndrome in which nitrate (converted to nitrite in the body) inhibits oxygen uptake, potentially leading to brain damage, or death (Welch 1991). The allowable level of nitrogen in drinking water for children ≤ 6 months old is 10 ppm (mg/1) as nitrate nitrogen (U.S. EPA 2002b).

Nitrogen enters aquatic ecosystems in one in of several forms including nitrate nitrogen (e.g. fertilizers), particulate nitrogen (e.g. litter fall from trees), ammonium (e.g. sewage and animal waste), and nitrous oxides from fossil fuel combustion (Schlesinger 1997). The means of entry into a system may differ for each type of nitrogen. For example, nitrous oxides enter by atmospheric deposition, nitrate often enters through groundwater, and particulate nitrogen follows terrestrial routes. Nitrogen is transformed by biological processes including uptake by plants and microbial denitrification, a process where anaerobic bacteria transform nitrate nitrogen to N_2, a gas phase of nitrogen (Schlesinger 1997). Only denitrification removes nitrogen from a system, whereas, nitrogen uptake by plants eventually returns nitrogen to the system through senescence and microbial decay. Nitrate nitrogen is of concern as an environmental stressor because it is biologically reactive, poses a human health risk, and often is found in groundwater.

Riparian buffers are thought to be an effective, sustainable means of buffering aquatic ecosystems against nutrient stressors such as nitrogen (Phillips 1989a) and thus are considered a best management practice (BMP) by State and Federal resource agencies (i.e., USDA-NRCS Environmental Quality Incentive Program, Conservation Programs Manual Part 515.91). Riparian buffers attenuate nitrogen through plant uptake, microbial immobilization and denitrification, soil storage, and groundwater mixing (Lowrance et al. 1997). The effectiveness of a buffer will depend upon its ability to intercept nitrogen in its various forms traveling along surface or subsurface pathways.

Often buffers are defined operationally as the zone of vegetation adjacent to streams, rivers, creeks, or wetlands (i.e., Lee et al. 2004). For this paper, riparian buffer, riparian zone, buffer strip, filter strip, and vegetated filter strip are terms used synonymously. However, these terms may be defined differently depending on the application and agency in question. Regardless of terminology, the extent to which riparian buffers attenuate nitrogen and improve stream water quality is thought to be at least partly a function of buffer width (Vidon and Hill 2004), by some estimates, accounting for 81% of a buffer's nitrogen removal effectiveness (Phillips 1989a). Intuitively, larger and wider riparian buffers should transform and remove more nitrogen from the watershed. Therefore, numerous State and Federal resource agencies have guidelines recommending buffers of minimum width to protect stream ecosystems from nutrient inputs (Belt et al. 1992, Christensen 2000, Lee et al. 2004.). Despite this trend toward regulation of riparian buffer widths, the specific mechanisms responsible for removing nitrogen within buffers are not thoroughly understood. Furthermore, what is known is not widely distributed to those who might be able to utilize the information to manage and restore riparian buffers to maintain water quality (Hickey and Doran 2004). An urgent need exists for guidance on proper and effective use of buffers to maintain water quality.

The purpose of this document is to identify causation and trends in the relationship between buffer width and nitrogen removal capacity extracted from peer-reviewed studies with empirical data on buffer effectiveness. Our secondary objective was to survey the State and Federal regulations and guidelines regarding riparian buffers to determine if buffer widths required under current law are consistent with effective buffer widths identified from the peer-reviewed literature.

Literature Survey Methods

We employed database search engines (e.g., Cambridge Abstracts, Google Scholar, etc.) and existing bibliographies (e.g., Correll 2003) to locate riparian buffer zone literature. We used search terms singly or combination including: riparian, buffer, width, filter strip, vegetated filters, nitrogen, etc. We summarized the conclusions from comprehensive and regional literature syntheses and the results from peer-reviewed research papers that contained original data quantifying the effects of riparian buffer width on nitrogen attenuation. We also surveyed Federal agency documents and previously published reviews of buffer width literature for opinions and recommendations on minimum effective buffer width. Papers that did not relate nitrogen removal to buffer width were not included in the results. Data presented in proceedings and other non-peer-reviewed sources were generally not included here except as part of generalizations presented in other literature reviews because methods therein could not be verified. We placed greater emphasis on studies that quantified a rate of nitrogen removal calculated per unit distance or per unit area. Such data may provide a quantifiable estimate of buffer effectiveness and aid in establishing minimum buffer widths based on removal effectiveness.

We also surveyed relevant Federal and State regulation codes, peer-reviewed literature reviews of government guidelines, and recommendations by government agencies that were not part of regulatory legislation. We attempted to locate Federal regulations and laws concerning riparian buffers by searching the web versions of the United States Code, Public and Private Laws, and the Code of Federal Regulations. Various agency websites were searched, including the websites of the United States Department of Agriculture (USDA), the United States Forest Service (USFS), the United States Army Corps of Engineers (USACE), the Bureau of Land Management (BLM), and the Government Accountability Office (GAO). We spoke directly with agency officials to clarify findings and to aid in the search for other regulations. Federal and State regulations and recommendations were compared to the previous literature-based results on riparian zones to determine the degree of consistency between them.

Results

Synthesis of Published Reviews on Buffer Effectiveness

We found 14 comprehensive and regional reviews of riparian buffer literature, most of which contained generalizations and recommendations based on both peer-reviewed and non-peer-reviewed research. In general, riparian forest vegetation and wetlands have been demonstrated as effective nutrient filters, particularly those between ~10-50 m wide (Belt et al. 1992, Johnson and Ryba 1992, Castelle et al. 1994, Fennessy and Cronk 1997, Fischer and Fischenich 2000, Christensen 2000). Narrower riparian buffers (5-6 m) may still reduce subsurface nitrate flows by up to ~80% (Muscutt et al. 1993, Parkyn 2004). However, extensive experimental support for buffer zones <10 m, like those used extensively on many farms, is lacking (Hickey and Doran 2004). Furthermore, riparian buffer zones >30 m were recommended for fully effective subsurface nutrient reduction (Muscutt et al. 1993, Wenger 1999). According to Wenger and Fowler (2000), "The most effective buffers are at least 30 meters, or 100 feet, wide composed of native forest, and are applied to all streams, including very small ones." The use of riparian buffers to filter nutrients from surface flow was not recommended by Barling and Moore (1994) because dissolved nitrate was not significantly reduced.

Groundwater flow paths, soil characteristics (i.e., moisture storage, hydraulic conductivity, roughness, and slope), seasonal, and climate may significantly impact the rate and magnitude of subsurface nitrate removal. Groundwater flow above shallow, impermeable soil layers maximizes water residence time and contact with plant roots and organic-rich soils, thereby increasing the potential for nitrate removal by plant uptake and microbial activity (Hill 1996, Christensen 2000). Considerably less nitrate removal per unit distance occurred where local or regional groundwater flowed at deeper depths or through organically-poor soil (Hill 1996). Where groundwater bypassed the root zone and surface soil layers, the retention of nitrogen was minimal (Lowrance et al. 1997).

Detailed Insight into the Peer-Reviewed Literature about Buffer Effectiveness

Vegetated buffers around wetlands

Wetland buffer zones were highly variable in their effectiveness, removing from 12-80% of surface water nitrogen (Yates and Sheridan 1983, Brüsch and Nilsson 1993). However, much faster nitrate reductions can occur in the groundwater of wetlands where, in some cases, >95% of nitrate can be removed within 1 m (Burns and Nguyen 2002). Brüsch and Nilsson (1993) documented temperature and seasonal components to nitrate reductions in surface runoff across a 15-25 m wide peat wetland. Average nitrate reduction was 73.7% in the summer, 12.2% during the first winter, but ~38% during the second winter season due to higher temperatures. Despite seasonal variance in mean surface runoff nitrate concentration of 15 to 50 ppm, nitrate concentration in an adjacent stream did not exceed 5 ppm throughout the study. Seasonal patterns, but with higher percentage of nitrate reduction (>90%), also were noted in a 200-m wide reed and alder wetland within a river channel scar (Fustec et al. 1991).

Wetland buffers on soils with limited organic matter (i.e., sand or gravel) tended to show lower capacity to remove nitrogen. Cooper (1990) found that, while subsurface nitrate removal from highly organic, saturated soils was ~90%, removal from within mineral colluvial soils was much less effective. Clausen et al. (2000) observed a 52-76% reduction in subsurface nitrate concentrations (95% of all nitrate loss) across a 5-m "poorly to very poorly drained alluvium wetland." Hanson et al. (1994) and Vellidis et al. (2003) observed similar reductions in nitrate (59% and 78%, respectively) from sandy, forested wetlands (31 and 38 m wide, respectively). Under "severely suboptimal conditions" in forested wetlands (i.e., sparsely vegetated, poorly drained, bottomland soils), riparian buffer widths <100 m were estimated to be 90% efficient at removing nutrients from agricultural runoff. However, under less severe conditions, buffer widths of 40-80 m on poorly drained soils and 15-60 m on well-drained soils were estimated to remove most nutrient runoff passing through a forested wetland, riparian zone (Phillips 1989b).

Forested buffers

The attenuation of nitrogen from groundwater flow can be rapid in forested riparian buffer zones. Schoonover and Willard (2003) found that 10-m forested buffers reduced groundwater nitrate concentration by 61%. Another study found a buffer averaging 38-m wide reduced nitrate concentration by 78% and ammonium by 52% (Vellidis et al. 2003). Others have documented more than 85% nitrate removal within the first 5 m of a buffer and 90-99% removal within 10-50 m of a buffer (Jacobs and Gilliam 1985, Lowrance 1992, Cey et al. 1999). As with wetland riparian buffers, most of the N transformation (~75%) occurred within the subsurface flow (Peterjohn and Correll 1984, Osbourne and Kovacic 1993). Furthermore, mature forests were 2-5 times more effective than "managed" (i.e., clearcut or selectively thinned) forests (Lynch et al. 1985, Hubbard and Lowrance 1997). Kuusemets et al. (2001) estimated that 85% of total nitrogen was retained in a heavily polluted 51-m wide riparian buffer, whereas only 40% of total nitrogen was retained in a buffer 31 m wide. Riparian buffers 100 m and 200 m wide in North Carolina removed from 67%-100% of groundwater nitrate entering the stream (Spruill 2004).

Effectiveness of nitrogen removal in forested riparian zones can vary widely due to characteristics unrelated to width. Extreme nitrogen loading (Lowrance et al. 1997) and increased hydraulic conductivity of the soil (Pinay and Decamps 1988, Pinay et al. 1993, Sabater et al. 2003) decrease effectiveness of forested riparian buffer zones. In some cases, these conditions can result in a net increase in nitrate concentrations in the groundwater (Sabater et al. 2003, Groffman et al. 2003) and can double the necessary width of the riparian zone for effective nutrient removal (Kuusemets et al. 2001). Spruill (2000) observed no difference in deep, "old" (>20 yr) groundwater underneath riparian zones with and without forested 30-m buffers, but 65-70% nitrate removal in shallow, "young" (<20 yr) groundwater through "reduction or denitrification." Effects of buffer width and length were mixed in a New Zealand study of forested buffers. However, oldest, longest (longitudinal), and widest (lateral) buffers had the greatest total nitrogen reductions (Parkyn et al. 2003). Saturated conditions led to removal of all nitrate within the first 30 m of forested riparian buffers in France (Pinay and Decamps 1988).

Grasslands

Grassed buffers or filter strips used alone or in conjunction with woody vegetation also can be effective at removing nitrogen. A 7.1-m grass buffer removed 80% of the total nitrogen and 62% of nitrate. Addition of a 9.2-m woody buffer to the grass buffer (total 16.3 m) increased effectiveness by 20%, removing 94% of the total nitrogen and 85% of the nitrate in runoff. However, effectiveness of the buffers in this study was negatively related to intensity of rainfall events (Lee et al. 2003). Giant cane (*Arundinaria gigantea*) reduced nitrate levels 90% in the first 3.3 m of the buffer, and 99% over 10 m, an effectiveness promoted by saturated conditions from upwelling groundwater (Schoonover and Williard 2003). In a study of seven herbaceous and herbaceous/forested riparian buffers in Canada, 90% removal of nitrate occurred 15 to 37 m into the riparian buffer depending on soil types and depth of the confining layer (Vidon and Hill 2004). Conversion of a portion of a corn field (*Zea mays* L.) to a riparian buffer of fine leaf fescue (*Festuca* spp.) decreased overland flow concentrations of total Kjeldahl nitrogen (TKN) by 70% and nitrate by 83% over the control and reduced nitrate concentrations in groundwater by 35%. Most (52%) of the nitrate decrease occurred within a 2.5-m wetland adjacent to the stream (Clausen et al. 2000).

In an Italian study, a 6-m wide grass/forest buffer (5-m grass + 1-m trees) reduced groundwater nitrate by >90% from maximum concentrations of ~25-28 ppm ($\bar{x}$ = 6.2) under the application field to a level always ≤2 ppm ($\bar{x}$ = 0.6) in groundwater (Borin and Bigon 2002). Grass buffers <5 m wide were ineffective in removing total nitrogen from surface runoff; those <10 m, but >5 m, wide were found to be 29-65% effective (Magette et al. 1989, Schmitt et al. 1999). Addition of a "forested" component to the grass buffer did not increase effectiveness (Schmitt et al. 1999). Grass filter strips 4.6 and 9.1 m wide reduced surface nitrate runoff from no-till cornfields by 27 and 57%, respectively. However, similar filter strips installed below animal feedlots were completely ineffective, yielding net gains in surface runoff nitrate concentrations (Dillaha et al. 1988, 1989).

Meta-Analysis of the Peer-Reviewed Literature about Buffer Effectiveness

Methods

Few peer-reviewed studies experimentally quantify nitrogen removal based specifically on riparian zone width. Rather, most studies measure nitrogen depletion at various locations throughout the riparian zone and/or in relation to biotic and abiotic variables such as vegetation or soil type. The lack of standardized field tests to quantify nitrogen removal based on buffer width sometimes makes comparisons among studies difficult. However, generalizations can be made based on the trends among 40 studies yielding 66 buffer width-effectiveness relationships (Table 1). In order to facilitate these generalizations and analyses, we grouped studies by vegetative cover type (i.e., wetland, forested, grassland) and by hydrologic flow conditions (e.g., surface vs. subsurface), factors that may influence nutrient attenuation in riparian buffer zones. We calculated nitrogen removal effectiveness (%) as 1) the % difference in nitrogen concentration between the influent into and effluent out of the riparian buffer, 2) % difference in nitrogen concentration between the terminus of the control buffer and that of the test buffer, or 3) if recalculation was impossible based on available data, the values presented by the authors were used directly (Table 1). These effectiveness data were plotted against buffer width, and linear and non-linear regression models were fitted to the data to reveal patterns of nitrogen removal based on width, buffer type, and hydrology. Though nitrate (NO_3^-) was the form of nitrogen most often measured among studies, we did not distinguish among nitrogen forms when calculating effectiveness. All buffers included in studies for which efficiencies could be calculated were included in the meta-analyses as independent data points. We then examined the relationship between loads (influents) and efficiencies to determine if thresholds existed for N removal. For studies that reported the actual influent nitrogen concentrations, we calculated the ratio of nitrogen load to buffer width as a measure of the level of impact to buffers and then used that ratio as the independent variable and nitrogen removal effectiveness as the dependent variable in a linear regression model to estimate buffer thresholds for nitrogen removal. Analyses were performed with SYSTAT version 11 (SPSS 2004).

Results

We found that nitrogen removal effectiveness varied widely among studies (Table 1) but overall, buffers were effective at removing large proportions of the nitrogen found in water flowing through riparian ecosystems (mean % ± 1SE: 74.2 ± 4.0; Table 2). A small but significant proportion of the variance in removal of nitrogen was explained by buffer width (R^2 = 0.14, N = 66; Figure 1). That is, wider buffers removed more nitrogen, but other factors also must have affected effectiveness. Additionally, greater consistency of nitrogen removal was evident with increasing buffer width (Figure 1). For example, nitrogen removal effectiveness in buffers <50 m wide was more variable than those >50 m where nearly all buffers exhibited about a 75% removal effectiveness (Figure 1). Thus, wider buffers are more likely to be efficient zones of nitrogen removal, whereas, narrower buffers may not always remove significant portions of nitrogen. Based on our non-linear regression model, 50%, 75%, and 90% removal efficiencies would occur in buffers approximately 3 m, 28 m, and 112 m wide, respectively (Figure 1, Table 2).

We found that nitrogen removal effectiveness also differed by flow pattern. Subsurface removal of nitrogen was much more efficient than surface removal (mean % ± 1SE: subsurface 89.6 ± 1.8, N = 48; surface 33.3 ± 7.7, N = 18; t = 10.1, P < 0.001; Figure 2). Furthermore, subsurface removal of nitrogen did not appear to be related to buffer width (R^2 = 0.02, N = 48; Figure 3), whereas, a small but significant proportion of the variance in surface removal of nitrogen was explained by buffer width (R^2 = 0.29, N = 18; Figure 3). That is, wider buffers removed more nitrogen in surface runoff. While some narrow buffers (1-15 m) removed significant proportions of nitrogen, three studies found that narrow buffers actually contributed nitrogen to riparian zones (i.e. had negative effectiveness values; Table 1). Such cases are likely to be short-term events due to nitrification or high rainfall events that lead to rapid inputs of particulate nitrogen. Based on our non-linear regression model, 50%, 75%, and 90% nitrogen removal efficiencies in surface flow would occur in buffers approximately 34, 118, and 247 m wide, respectively (Figure 3, Table 2).

We also found that nitrogen removal effectiveness varied by buffer vegetation type (N = 66; F = 4.8, P = 0.002; Figure 4 and Table 2). Grass buffers were significantly less effective than forest buffers at removing nitrogen (P = 0.001, Bonferroni adjustment), whereas, other buffers were equally effective (Figure 4).

Forested and wetland buffers showed no relationship between buffer width and nitrogen removal effectiveness (Figure 5). However, grass buffer effectiveness increased with buffer width in a non-linear fashion (Figure 5). Grass and grass/forest buffers were not always effective at removing nitrogen and, in three cases where buffers were <10 m, actually added to nitrogen loads (Figure 5). Based on the non-linear model results, we calculated the approximate buffer widths by vegetative types necessary to achieve 50%, 75%, and 90% effectiveness (Table 2). Nitrogen removal efficiencies of 50%, 75%, and 90% were predicted for grass buffers approximately 16, 47, and 90 m wide and for grass/forest buffers approximately 5, 20, and 47 m wide, respectively. Given the low R^2 values, buffer widths could not be predicted for effective nitrogen removal for grass or grass/forest buffers (Table 2). Note also, that the relationship between buffer width and effectiveness for forested wetlands was negative (Figure 5), suggesting that narrow forested wetland buffers are more effective than wide buffers. This non-intuitive result is likely due to the small sample size and not a cause and effect relationship. Therefore, buffer widths were not predicted for this vegetation type. Subsurface removal of nitrogen was generally high regardless of vegetation type, whereas, surface removal was less efficient and more variable among all buffer vegetation types (Figure 6).

In a similar meta-analysis with a more limited data set but fitting the same non-linear model as here, Oberts and Plevan (2001) found that nitrate nitrogen retention in wetland buffers was positively related to buffer width (R^2 values ranged from 0.35 – 0.45). Nitrogen removal efficiencies of 65-75% and 80-90% were predicted for wetland buffers 15 m and 30 m wide, respectively, depending on whether nitrate nitrogen was measured in surface or subsurface flow.

Finally, we found evidence for a threshold of nitrogen removal in buffers based on the nitrogen load entering the buffer. We calculated a ratio of nitrogen influent (pmm) to buffer width (m) for all studies that quantified influent loads and then fitted a linear model with nitrogen removal effectiveness as the dependent variable. Nitrogen removal effectiveness declined as the nitrogen load to width ratio increased (R^2 = 0.11, P = 0.02, N = 55; Figure 7). That is, buffer effectiveness declined when nitrogen loads were high relative to buffer width. However, five studies showed low or no nitrogen removal effectiveness even when nitrogen loads were small relative to buffer width (Figure 7), a pattern due to the ineffectiveness of nitrogen removal in surface flows. Thus, these data were highly variable but imply a threshold for nitrogen removal in buffers suggesting that reducing buffer width will risk nitrogen contamination to watersheds.

Table 1. Summary Table of Riparian Buffer Effectiveness at Removing Nitrogen by Vegetative Cover, Hydrologic Flow Path, Buffer Width and Soil Type. ("nd" = not detected; "–" = data not provided by authors)

Vegetative Cover Type	Flow Path	Buffer Width	N form	Mean Influent (pmm)	Mean Effluent (pmm)	Effectiveness(%)	Major Soil type(s)	Study
grass	surface	4.6	total N	–	–	-15	sandy loam	Magette et al. 1989
grass	surface	9.2	total N	–	–	35	sandy loam	Magette et al. 1989
grass	surface	7.5	total N	68	44	35	silty clay loam	Schmitt et al. 1999
grass	surface	15	total N	68	33	51	silty clay loam	Schmitt et al. 1999
grass	surface	4.6	nitrate	1.86	2.37	-27	silt loam	Dillaha et al. 1988
grass	surface	9.1	nitrate	1.86	2.13	-15	silt loam	Dillaha et al. 1988
grass	surface	4.6	nitrate	–	–	27	silt loam	Dillaha et al. 1989
grass	surface	9.1	nitrate	–	–	57	silt loam	Dillaha et al. 1989
grass	surface	91	total N	21.6	13.3	38	–	Zirschky et al. 1989
grass	surface	27	nitrate	0.37	0.34	8	–	Young et al. 1980
grass	surface	26	NH_3	3.61	3.05	16	very fine sandy loam	Schwer and Clausen 1989
grass	surface	26	TKN	48.9	11.76	76	very fine sandy loam	Schwer and Clausen 1989
grass	subsurface	25	nitrate	15.5	6.2	60	coarse sand	Vidon and Hill 2004b
grass	subsurface	70	nitrate	1.55	0.32	80	fine sandy loam/silt loam	Martin et al. 1999
grass	subsurface	39	nitrate	16.5	3	82	silty clay loam	Osborne and Kovacic 1993
grass	subsurface	25	nitrate	12.15	1.92	84	peat/sand	Hefting and de Klein 1998
grass	subsurface	16	nitrate	2.8	0.3	89	stony clay loam	Haycock and Burt 1993
grass	subsurface	10	nitrate	7	0.3	96	entisols/histosols	Hefting et al. 2003
grass	subsurface	100	nitrate	375	<5	98	–	Prach and Rauch 1992
grass	subsurface	10	nitrate	7.54	0.05	99	silt loam	Schoonover and Williard 2003
grass	subsurface	30	nitrate	44.7	0.45	99	sand/loamy sand	Vidon and Hill 2004b
grass	subsurface	50	nitrate	6.6	0.02	100	fine sandy loam	Martin et al. 1999

Table 1. Continued.

Vegetative Cover Type	Flow Path	Buffer Width	N form	Mean Influent (pmm)	Mean Effluent (pmm)	Effectiveness(%)	Major Soil type(s)	Study
grassforest	surface	7.5	total N	68	49	28	silty clay loam	Schmitt et al. 1999
grassforest	surface	15	total N	68	40	41		
grassforest	subsurface	6	nitrate	6.17	0.56	91	loam/sandy loam	Borin and Bigon 2002
grassforest	subsurface	70	nitrate	11.98	1.09	91	loamy sand	Hubbard and Lowrance 1997
grassforest	subsurface	66	nitrate	5.8	0.17	97	gravel	Vidon and Hill 2004b
grassforest	subsurface	33	nitrate	5.7	0.11	98	sandy loam/loamy sand	Vidon and Hill 2004b
grassforest	subsurface	45	nitrate	17.8	0.18	99	peat	Vidon and Hill 2004b
grassforest	subsurface	70	nitrate	1.65	0.02	99	fine sandy loam/silt loam	Martin et al. 1999
forest	surface	30	nitrate	0.37	0.08	78	silt/stony loam	Lynch et al. 1985
forest	surface	70	nitrate	4.45	0.94	79	fine sandy loam	Peterjohn and Correll 1984
forest	subsurface	50	nitrate	26	11	58	entisols/histosols	Hefting et al. 2003
forest	subsurface	200	nitrate	11	4	64	medium-coarse sand	Spruill 2004
forest	subsurface	10	nitrate	6.29	1.15	82	silt loam	Schoonover and Williard 2003
forest	subsurface	55	nitrate	–	–	83	–	Lowrance et al. 1984
forest	subsurface	20	nitrate	–	–	83	–	Schultz et al. 1995
forest	subsurface	85	nitrate	7.08	0.43	94	fine sandy loam	Peterjohn and Correll 1984
forest	subsurface	204	nitrate	29.4	1.76	94	peat/sand/gravel	Vidon and Hill 2004b
forest	subsurface	50	nitrate	13.52	0.81	94	loamy sand	Lowrance 1992
forest	subsurface	60	nitrate	8	0.4	95	sand/gravel/clay	Jordan et al. 1993
forest	subsurface	16	nitrate	16.5	0.75	95	silty clay loam	Osborne and Kovacic 1993

Table 1. Continued.

Vegetative Cover Type	Flow Path	Buffer Width	N form	Mean Influent (pmm)	Mean Effluent (pmm)	Effectiveness(%)	Major Soil type(s)	Study
forest	subsurface	16	nitrate	6.6	0.3	95	stony clay loam	Haycock and Pinay 1993
forest	subsurface	15	nitrate	–	–	96	–	Hubbard and Sheridan 1989
forest	subsurface	165	nitrate	30.8	1	97	peat/sand	Hill et al. 2000
forest	subsurface	50	nitrate	6.26	0.15	98	peat/sand	Hefting and de Klein 1998
forest	subsurface	220	nitrate	10.8	0.22	98	peat/loamy sand	Vidon and Hill 2004b
forest	subsurface	50	nitrate	7.45	0.1	99	loamy sand	Jacobs and Gilliam 1985
forest	subsurface	10	nitrate	13	0.1	99	silt loam	Cey et al. 1999
forest	subsurface	100	nitrate	5.6	0.02	100	sandy clay/coarse sand	Spruill 2004
forest	subsurface	30	nitrate	1.32	nd	100	silt clay	Pinay and Decamps 1988
forest	subsurface	100	nitrate	12	nd	100	silt/plant debris/sand	Spruill 2004
forestwetland	surface	–	nitrate	0.34	0.07	81	sand	Yates and Sheridan 1983
forestwetland	subsurface	31	nitrate	62.7	25.9	59	sand	Hanson et al. 1994
forestwetland	subsurface	38	nitrate	30.6	6.7	78	sandy loam	Vellidis et al. 2003
forestwetland	subsurface	14.6	nitrate	–	–	84	sandy mixed mesic	Simmons et al. 1992
forestwetland	subsurface	5.8	nitrate	–	–	87	sandy mixed mesic	Simmons et al. 1992
forestwetland	subsurface	5.8	nitrate	–	–	90	sandy mixed mesic	Simmons et al. 1992
forestwetland	subsurface	6.6	nitrate	–	–	97	loamy mixed mesic	Simmons et al. 1992
forestwetland	subsurface	30	nitrate	1.06	nd	100	clay loam	Pinay et al. 1993
wetland	surface	20	nitrate	57	50	12	peat/sand	Brüsch and Nilsson 1993
wetland	surface	20		57	15	74		
wetland	subsurface	5	nitrate	6.56	1.55	76	stony silt loam	Clausen et al. 2000
wetland	subsurface	5		3	1.44	52		
wetland	subsurface	1	nitrate	1	–	96	clay loam/clay	Burns and Nguyen 2002
wetland	subsurface	200	nitrate	10.5	0.5	95	silt/sand/gravel	Fustec et al. 1991
wetland	subsurface	40	nitrate	77.48	0.31	100	fine to coarse sand	Puckett et al. 2002

Table 2. Mean and Percent Effectiveness of Riparian Buffers at Removing Nitrogen. Buffer Widths Necessary to Achieve a Given Percent Effectiveness (50%, 75%, 90%) are Approximate Values Predicted by the Non-Linear Model, y=a*ln(x)+b. Effectiveness was not predicted (np) for Models with R^2 Values <0.2

Flow Path or Vegetative cover type	N	Mean nitrogen removal effectiveness (%)	1SE	Relationship to buffer width		Approximate buffer width (m) by predicted effectiveness		
				Model	R^2	50%	75%	90%
All studies	66	74.2	4.0	y = 10.5*ln(x) + 40.5	0.137	3	28	112
Surface flow	18	33.3	7.7	y = 20.2*ln(x) – 21.3	0.292	34	118	247
Subsurface flow	48	89.6	1.8	y = 1.4*ln(x) + 84.9	0.016	np	np	np
Forest	22	90.0	2.5	y = -0.7*ln(x) + 92.5	0.003	np	np	np
Forested Wetland	7	85.0	5.2	y = -7.3*ln(x) + 104.3	0.203	np	np	np
Grass	22	53.3	8.7	y = 23.0*ln(x) – 13.6	0.277	16	47	90
Grass/forest	8	80.5	10.2	y = 18.1*ln(x) + 20.4	0.407	5	20	47
Wetland	7	72.3	11.9	y = 3.0*ln(x) + 68.9	0.005	np	np	np

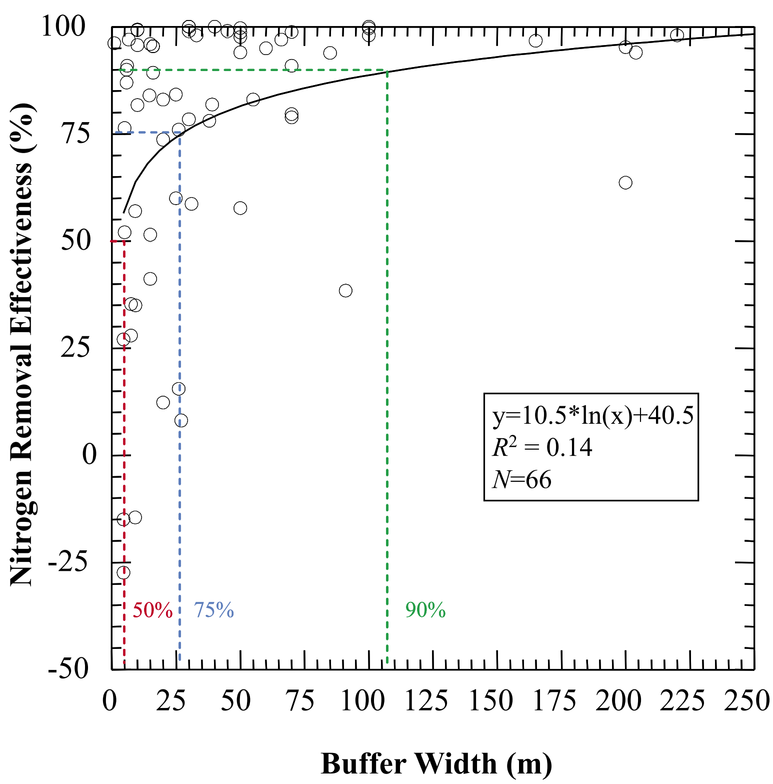

Figure 1. *Relationship of nitrogen removal effectiveness to riparian buffer width. All studies combined. Lines indicate probable 50%, 75%, and 90% nitrogen removal efficiencies based on the fitted non-linear model.*

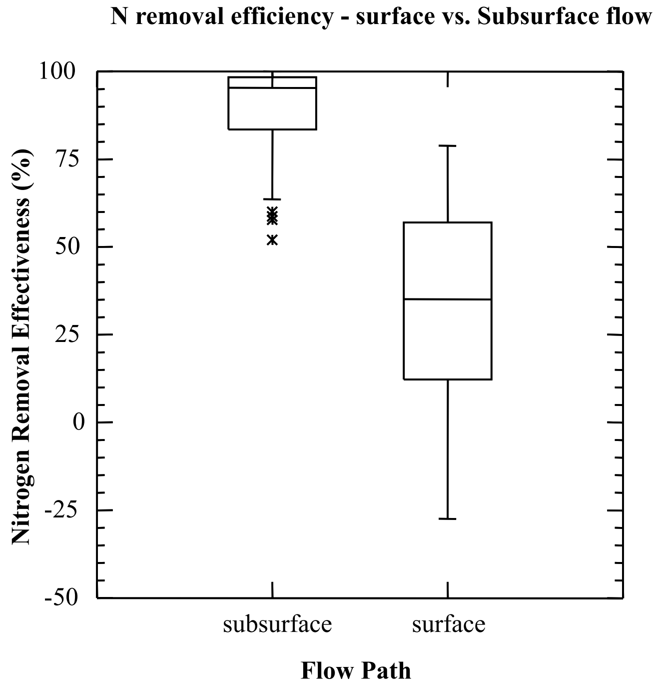

Figure 2. *Nitrogen removal effectiveness in riparian buffers by flow path. The center vertical line of the box and whisker plot marks the median of the sample. The length of each box shows the range within which the central 50% of the values fall. Box edges indicate the first and third quartiles. Whiskers show the range of observed values that fall within the midrange of the data. Asterisks indicate outside values.*

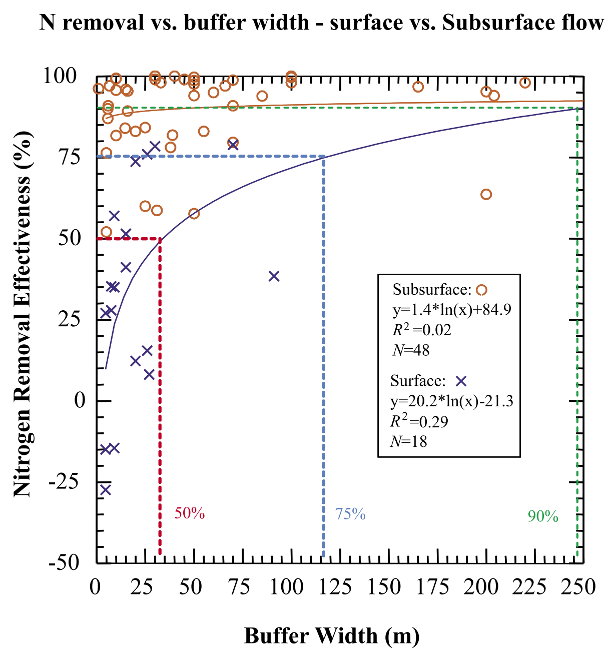

Figure 3. *Relationship of nitrogen removal effectiveness to riparian buffer width by flow path. Lines indicate probable 50%, 75%, and 90% nitrogen removal efficiencies in the surface flow path based on the fitted non-linear model.*

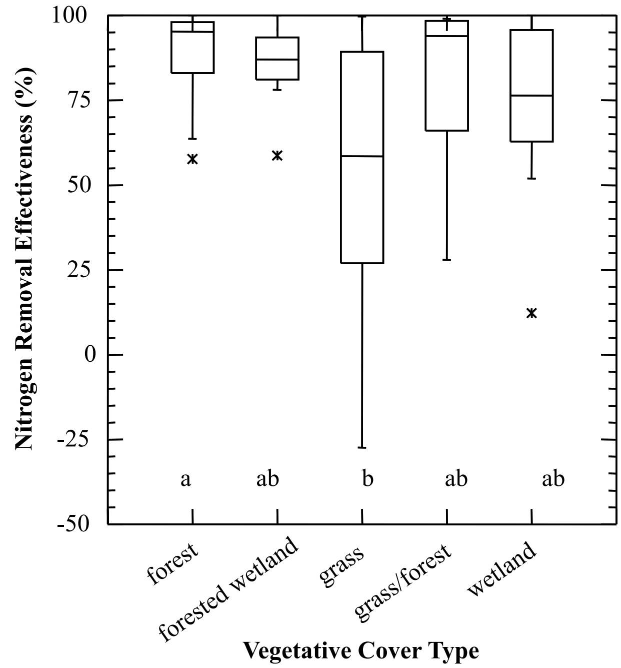

Figure 4. *Nitrogen removal effectiveness in riparian buffers by buffer vegetation type. The center vertical line of the box and whisker plot marks the median of the sample. The length of each box shows the range within which the central 50% of the values fall. Box edges indicate the first and third quartiles. Whiskers show the range of observed values that fall within the midrange of the data. Asterisks indicate outside values. Boxes identified with the same letters are not significantly different (P > 0.05).*

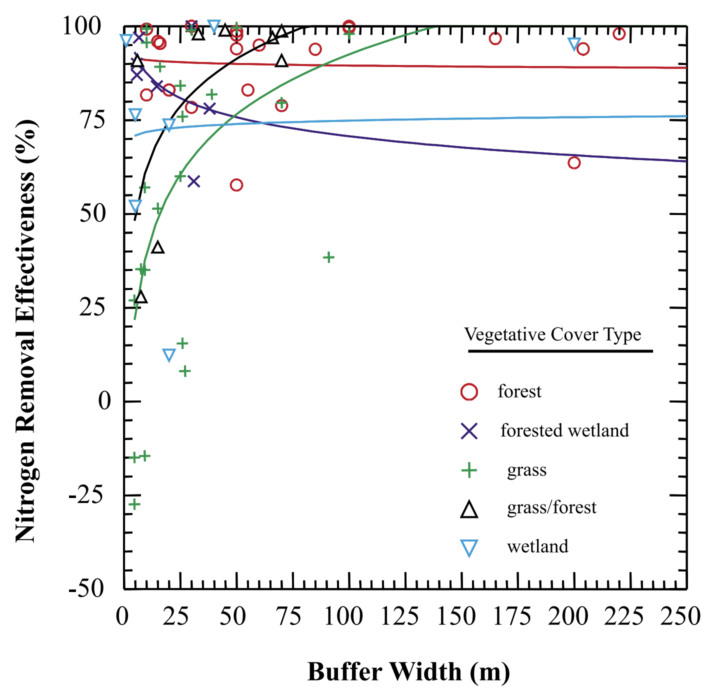

Figure 5. *Relationship of nitrogen removal effectiveness to riparian buffer width by riparian vegetation type. Curves are fitted to non-linear model: $y = a*\ln(x) + b$*

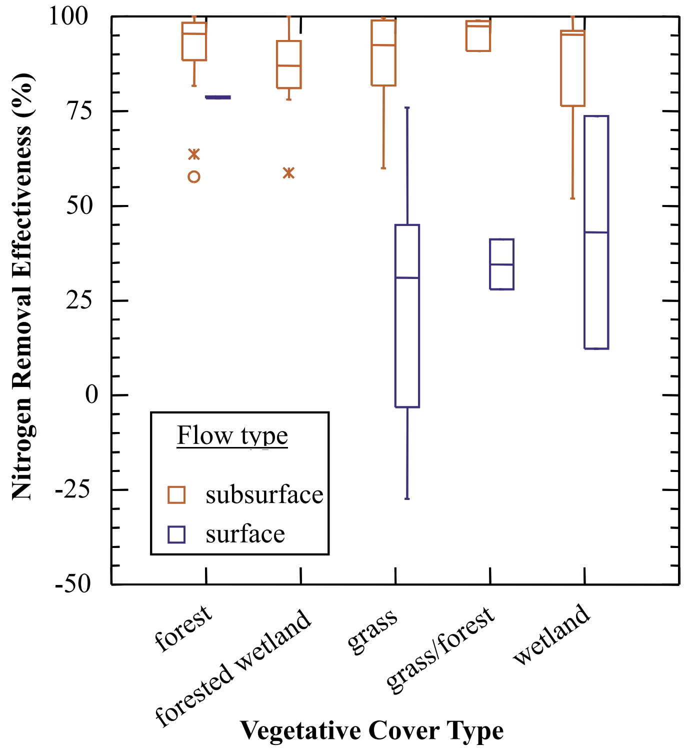

Figure 6. *Nitrogen removal effectiveness in riparian buffers by buffer vegetation type and water flow path. The center vertical line of the box and whisker plot marks the median of the sample. The length of each box shows the range within which the central 50% of the values fall. Box edges indicate the first and third quartiles. Whiskers show the range of observed values that fall within the midrange of the data. Asterisks indicate outside values.*

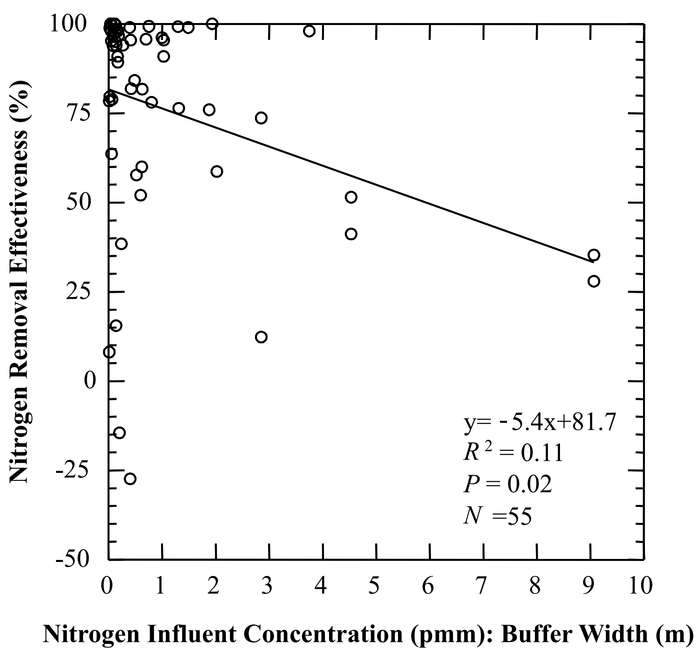

Figure 7. *Relationship of nitrogen removal effectiveness to nitrogen load:buffer width ratio. Fitted to linear model: y=a(x)+b.*

Discussion

Our meta-analysis suggests that nitrogen removal in the subsurface may be more directly influenced by soil type, watershed hydrology (e.g., soil saturation, groundwater flow paths, etc.), and subsurface biogeochemistry (organic carbon supply, high nitrate inputs) through cumulative effects on microbial denitrification activity than on buffer width per se. Surface flows bypass zones of denitrification and thus effectively remove nitrogen only when buffers are wide enough and have adequate vegetation cover to control erosion and filter movement of particulate forms of nitrogen. Grass buffers, for example, may be better at intercepting particulate nitrogen in the sediments of surface runoff by reducing channelized flow.

Federal Regulations and Recommendations

United States Code (USC)

Riparian buffers are noted in at least 14 parts within the USC (Appendix 1). Under the auspices of the 1972 Federal Water Pollution Control Act or Clean Water Act (33USC1251 et seq. as amended through P.L. 107–303, November 27, 2002), the U.S. EPA publishes lists of impaired waters for which Total Maximum Daily Loads (TMDL) are established that limit the amount of a pollutant, including nitrogen, that a water body can receive and remain compliant with State water quality standards (33USC1251.319). States are required to implement BMP's, such as riparian buffers or vegetated filter strips, to achieve compliance. U.S. EPA provides generalized recommendations and funding for riparian buffers and filter strips as part of Comprehensive Nutrient Management Plans (U.S. EPA 2001, 2003). However, site-specific BMP approaches and implementation are the jurisdiction of the States.

No comprehensive Federal statutory laws exist directly dealing with riparian buffer width even though buffers are mentioned in the USC. In some cases, site-specific legislation has been enacted that mandates protection of riparian buffers. The United States Congress has passed laws requiring vegetation to be left undisturbed on the sides of stream and river banks during specific activities. For example, in 16 USC 539(d), the National Forest Timber Utilization Program (a.k.a. the 1990 Tongass Timber Reform Act):

> "In order to assure protection of riparian habitat, the Secretary shall maintain a buffer zone of no less than one hundred feet in width on each side of all Class I streams in the Tongass National Forest, and on those Class II streams which flow directly into a Class I stream, within which commercial timber harvesting shall be prohibited…"

Timber harvesting from the National Forest System has also been regulated, in general, through the National Forest System Land and Resource Management Plan, which states, without providing strict guidelines, that harvesting plans must,

> "insure that timber will be harvested from National Forest System lands only where soil, slope, or other watershed conditions will not be irreversibly damaged" and where "protection is provided for streams, streambanks, shorelines, lakes, wetlands, and other bodies of water from detrimental changes in water temperatures, blockages of water courses, and deposits of sediment, where harvests are likely to seriously and adversely affect water conditions or fish habitat" (16 USC 1604).

Riparian conservation has been cited within the USC as one of the purposes for the establishment of National Parks and as directives to the Secretary of the Interior (e.g. 16 USC Sec. 460). As all national parks must follow the dual policy of both multiple and sustained yield, several subsections within this section of USC address riparian zones of other national parks likewise, to "contribute to public enjoyment," "protect important resource values," etc. In all cases, the statutes are site-specific, and the riparian zones discussed are between 100 and 300 ft.

Code of Federal Regulations (CFR)

Riparian buffers are noted in at least 47 parts within the CFR (Appendix 2). The CFR places blanket statutory restrictions on certain industrial practices in riparian areas. For instance, 30 CFR 816.57 and 30 CFR 817.57 prohibit surface and underground mining activities within 100 ft of perennial or intermittent streams, and 36 CFR 228.108 prohibits mining operations within the National Forest System "in areas subject to mass soil movement, riparian areas, and wetlands."

Voluntary participation programs such as the Conservation Reserve Program (CRP) and the Conservation Reserve Enhancement Program (CREP) provide landowners financial incentives to protect land and waterbodies through maintenance of buffers, wetlands, and by planting cover crops (7CFR1410). The CRP is administered through the U.S. Department of Agriculture's Farm Service Agency (USDA-FSA) (7CFR, Chap. VII) with technical assistance provided by the National Resources Conservation Service (USDA-NRCS) (7CFR, Chap. VI).

The USDA-FSA makes a distinction between filter strips and riparian buffers (7CFR1410.2). Filter strip is a "a strip or area of vegetation adjacent to a body of water the purpose of which is to remove nutrients, sediment, organic matter, pesticides, and other pollutants from surface runoff and subsurface flow by deposition, absorption, plant uptake, and other processes, thereby reducing pollution and protecting surface water and subsurface water quality and of a width determined appropriate for the purpose by the Deputy Administrator." No minimum widths are specified for construction of filter strips (NRCS 2003; practice Code 393).

Riparian buffer (NRCS 2003; practice Code 391) is "a strip or area of vegetation adjacent to a river or stream of sufficient width as determined by the Deputy Administrator to remove nutrients, sediment, organic matter, pesticides, and other pollutants from surface runoff and subsurface flow by deposition, absorption, plant uptake, and other processes, thereby reducing pollution and protecting surface water and subsurface water quality, which are also intended to provide shade to reduce water temperature for improved habitat for aquatic organisms and supply large woody debris for aquatic organisms and habitat for wildlife."

The importance of the distinction between filter strip and riparian buffer is in their implementation. For example, according to the CRP, riparian buffers should consist of three zones. Zone 1 starts at the top of the stream bank, is devoted to trees, and has a minimum width of 15 ft measured as perpendicular from the bank. Zone 2 is predominately composed of riparian trees and shrubs suitable to the site and has a minimum width of 20 ft. Zone 3 is only required for concentrated flow conditions and is devoted to native grasses and forbs (NRCS 2003). CRP limits enrollment of buffers constructed for water quality to those with less than a "maximum average width of 180 feet" and an absolute maximum width of 350 ft.

State and Provincial Regulations and Recommendations

State (USA) and Provincial (Canada) width guidelines for forested riparian buffers associated with timber harvesting were recently summarized by Lee et al. (2004). State width guidelines for buffers ranged from 15.5 – 24.2 m. Provincial guidelines generally required wider buffers (13.8 – 43.8 m). Widest buffers were recommended in northern Canada and narrowest in the southeastern U.S. In some areas, buffer widths were regulated as "one size fits all." Elsewhere, width recommendations were modified using factors including size/permanence of waterbody, slope of surrounding terrain, and presence/absence of fish.

In general, Lee et al. (2004) found that State-level "blanket" regulations addressing nitrogen attenuation and riparian buffer zone widths were non-existent. Many states have no mandatory buffer regulations and almost none regulate agriculture where buffers may have greatest potential for attenuating nitrogen fertilizer or livestock. However, many states have documented standards related to sections 303(d) and 319 of the CWA that result in site-specific maintenance of riparian zones for watershed protection, including nutrient attenuation. For resource agencies that do not yet have such regulations and wish to develop standards, numerous models and existing riparian buffer ordinances are available to serve as templates (U.S. EPA, undated; SCDHEC, undated). Many local governing bodies at the county, municipal, or district level proved additional guidance or regulation regarding riparian buffers. Wenger and Fowler (2000) indicated that establishing and enforcing regulations for variable-width buffers contingent upon local land use, slope, soil type, etc. are most difficult and suggest, rather, a model, fixed-width buffer ordinance intended to be clear and enforceable.

Other Aspects of Buffer Effectiveness

Buffer width partly accounts for nitrogen removal effectiveness of riparian buffers. However, other factors may be equally or more important in determining buffer effectiveness such as vegetation type and depth of the root zone where plants can take up nitrogen (Asmussen et al. 1979, Cooper 1990). Nitrogen also is consumed by denitrifying bacteria which convert nitrate to inert dinitrogen gas (Korum 1992). Therefore, riparian zones are particularly effective at removing nitrate where groundwater conditions favor denitrification, such as saturated soils that maintain anaerobic sites (Leeds-Harrison et al. 1999, Sloan et al. 1999, Sabater et al. 2003) and carbon supplies adequate for bacterial respiration in the subsurface (Hanson et al. 1994; Hill et al. 2000, 2004; Steinhart et al. 2001; Schade et al. 2001, 2002; Richardson et al. 2004). Therefore, narrow buffers may be effective if such groundwater characteristics promoting denitrification are present (Dillaha et al. 1989, Simmons et al. 1992) but, as our meta-analysis showed, wider buffers tended to be more effective. Streams with riparian zones that remain hydrologically connected with adjacent floodplains are more likely to function in ways that promote denitrification (Groffman et al. 2003; Groffman et al. 2005).

For maximum and long-term effectiveness, buffer integrity should be protected against a) soil compaction from vehicles, livestock, and impervious surfaces (e.g., pavement) that might inhibit infiltration or disrupt water flow patterns (Dillaha et al. 1989; NRC 2002), b) excessive leaf litter removal or alteration of the natural plant community (e.g., raking, tree thinning, introduction of invasive species) that might reduce carbon-rich organic matter from reaching the stream, and c) urbanization and other practices that might disconnect the stream channel from the flood plain (i.e., channelization, bank erosion, stream incision, and drain tiles) and thereby reduce the spatial and temporal extent of soil saturation (Paul and Meyer 2001, Groffman et al. 2003, Groffman et al. 2005). Buffer width may indirectly affect factors promoting denitrification. For example, narrow buffers that produce little vegetative biomass may not provide sufficient stocks of organic material for microbial denitrifiers.

Buffer Restoration, Planning, and Design

Creating ordinances and zoning to protect existing buffers will likely be cheaper than creating new buffers or restoring degraded ones. However, restoring buffers may be a necessary component of watershed water quality protection (FISRWG 1998, NRC 2002). An engineering approach thought to maximize nutrient removal capacity of buffers involves a multiple vegetation species or plant zone system (Welch 1991, Schultz et al. 1995, NRCS 2003). This 3-zone strategy was originally intended for protecting streams against timber harvest or agricultural use and is characterized by a zone of grasses and forbs immediately next to the area of disturbance, a middle zone of shrubs, and a zone of trees nearest to the stream channel. In theory, sediments and nutrients in surface runoff flowing from agricultural fields or timbered areas are intercepted first by the grass zone, while nutrients entering deeper subsurface pathways are taken up by shrub and tree roots (NRC 2002).

Substantial evidence exists to emphasize the importance of maintaining riparian zones in upstream headwaters or backwaters regions, which can be areas of high nitrogen removal (Perry et al. 1999, Morrice et al. 2000, Peterson et al. 2001, Seitzinger et al. 2002, Richardson et al. 2004, Bernhardt et al. 2005a). For a 10^{th} order stream, up to 90% of the cumulative stream length consists of ephemeral, first, and second order streams (NRC 2002). Thus, the largest proportion of annual stream nutrient load enters watersheds from the headwaters where the capacity to remove nitrogen is great, while less additional nitrogen processing occurs in the main channels of higher order streams (Richardson et al. 2004, Bernot and Dodds 2005).

Many stream restoration projects are conducted to re-establish geomorphic stability (Bernhardt et al. 2005b) using approaches that potentially alter nutrient and sediment dynamics (Steiger and Gurnell 2003) in ways that may promote conditions for denitrification such as increasing supply and burial of organic matter, reconnecting flood plains, and increasing hydraulic residence time (Groffman et al. 1996). Furthermore, removal of nitrate occurs within the stream channel after nutrients have moved through the riparian zone and entered the hyporheic zone (Peterson et al. 2001, Kemp and Dodds 2002) suggesting that, in addition to establishing riparian buffers, manipulation of stream channels to support denitrification also should be considered as a means to manage nutrients (Groffman et al. 2005).

Summary and Conclusions

Based on current studies, riparian buffers of various types are effective at reducing nitrogen in riparian zones, especially nitrogen flowing in the subsurface. Buffers generally are more effective where soil type, hydrology, and biogeochemistry are conducive to microbial denitrification and plant uptake. While some narrow buffers (1-15 m) removed nitrogen, wider buffers (>50 m) more consistently removed significant portions of nitrogen probably by providing more area for root uptake of nitrogen or more sites for denitrification.

On average, State guidelines (Lee et al. 2004) recommended buffer widths that corresponded well to the minimum effective buffer widths necessary to improve water quality only if conditions within buffers are conducive to denitrification. Federal regulations do not stipulate minimum buffer widths for nitrogen removal from streams. Rather, riparian buffers represent a suggested tool to protect stream water quality and/or for removing streams from impaired listing due to nitrogen pollution under 303(d) section of the Clean Water Act. Federally recommended buffer widths vary from ~7-100 m, which encompass the width range of buffers expected to remove significant amounts of nitrogen.

Buffers extending along the length of both stream banks and in which there is prolonged contact time with the root zone will offer greater likelihood of nitrogen uptake by plants. Buffers will be most effective at controlling nitrogen through denitrification when 1) water flow (overland and subsurface) is evenly distributed and soil infiltration rates are high, 2) anaerobic (saturated) conditions persist in the subsurface, and 3) sufficient organic carbon is present. Therefore, to maintain maximum effectiveness, buffer integrity should be protected against soil compaction, loss of vegetation, and stream incision. Maintaining buffers around stream headwaters will likely be most effective at maintaining overall watershed water quality while restoring degraded riparian zones, and stream channels may improve nitrogen removal capacity. However, because streams and riparian zones have limited capacity to process nitrogen, watershed nutrient management efforts also must include control and reduction of point and non-point sources of nitrogen from atmospheric, terrestrial, and aquatic inputs. In any case, riparian buffers are a “best management practice” (BMP) that should be used in conjunction with a comprehensive watershed management plan (U.S. EPA 1995, NRC 2002). Finally, riparian buffers are often protected to achieve multiple goals (e.g. sediment trapping, aesthetics, wildlife habitat), some of which may require wider buffers, specific vegetation types, and/or other special considerations (Castelle et al. 1994, Wenger 1999, Fischer and Fischenich 2000).

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Appendices

Appendix 1. *Summary Table of United States Code Referring to "Riparian", "Buffer", "Vegetated", and "Filter Strip". (Source: http://www.gpoaccess.gov)*

United States Code			
Title	**Chapter**	**Part(s)**	
16 - Conservation	1 - National Parks, Military Parks, Monuments, and Seashores	460	
	2 - National Forests	539	
	6 - Game and Bird Preserves, Protection	689	
	36 - Forest and Rangeland Renewable Resources Planning	1604	
	41 - Cooperative Forestry Assistance	2103	2140
	58 - Land and Wetland Conservation and Reserve Program	3831	3839
25 - Indians	11 - Irrigation of Alloted Lands	381	
33 - Navigation and Navigable Waters	9 - Protection of Navigable Waters and or Harbor and River Improvements Generally	465	
	11 - Bridges over Navigable Waters	500	
	36 - Water Resources Development	2336	
42 – The Public Welfare	19 - Water Resources Planning	1962	
43 - Public Lands	23 - Grants of Swamp and Overflowed Lands	994	

Appendix 2. *Summary Table of Code of Federal Regulations Referring to "Riparian", "Buffer", "Vegetated", and "Filter Strip". (Source: http://www.gpoaccess.gov)*

Code of Federal Regulations						
Title	**Chapter**	**Part(s)**				
7 - Agriculture	VI - National Resources Conservation Service	601	610			
	VII - Farm Service Agency	718				
	XIV - Commodity Credit Corporation	1410	1467	1469		
	XVII - Rural Utilities Service	1767				
	XVIII - Rural Housing Service, Rural Business Cooperative, Rural Utilities Service, and Farm Service Agency	1940	1943	1955		
10 - Energy	I - Nuclear Regulatory Commission	51				
18 - Conservation of Power and Water Resources	I – Federal Energy Regulatory Commission	5	380			
	XIII - Tennessee Valley Authority	1304				
30 - Mineral Resources	VII - Office of Surface	15	80	84	715	
		717	780	784	816	
		817				
36 - Parks, Forests, and Public Property	II - Forest Service	200	228	230	292	
40 - Protection of the Environment	I - Environmental Protection Agency	122	412			
43 - Public Lands, Interior	II - Bureau of Land Management	2420	2450	3420	3800	
		3809	4100	4120	4130	
	III - Utah Reclamation Mitigation and Conservation Commission	10005				
44 - Emergency Management and Assistance	I - Federal Emergency Management Agency	60	206	209		
50 - Wildlife and Fisheries	I - U.S. Fish and Wildlfe Service	17	36	37		
	II - National Marine Fisheries Service	222	223	226		

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EPA/600/R-05/118
October 2005